Technical Appendix:

Section 3. BMP Effectiveness

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TA-3.1 2008 BMP Monitoring Status

SPA projects and BMP monitoring requirements

A list of all properties with SPA BMP monitoring is provided in Table TA-3.1. The first part of the table provides structural monitoring requirements; the second part of the table provides monitoring requirements for other parameters. Any modifications or updates to monitoring requirements are located in Table TA-3.2.

Table TA-3.1. 2008 SPA project status with monitoring requirements.

If structural monitoring was required, the type of sampling – grab or automated – is specified. "Automated" denotes that flow-weighted composite samples were collected using automated sampling equipment.

SPA	No.	Project Name	Monitoring Phase (during 2008)	Structural Monitoring	
				S&EC Structure	SWM Structure
Clarksburg	1	All Souls Cemetery	Complete (2008)	No	No
	2	Cabin Branch	Pre-construction (construction anticipated 2010)	Yes - Automated	Yes - Automated
	3	Catawba Manor	Complete (2008)	No	No
	4	Clarksburg Detention Center (Jail)	Complete (2003)	Yes - Grab	No - Requirement dropped
	5	Clarksburg Ridge	Post Construction	Yes - Grab	Yes - Automated
	6	Clarksburg Town Center	During Construction; nearing post construction	Yes - Automated	Yes - Automated
	7	Clarksburg Village (w/Greenway Trail)	During Construction; nearing post construction for Phase I	Yes - Grab	Yes - Automated; 3 structures
	8	Eastside	Pre-construction; on hold	Yes - Automated	Yes - Automated
	9	Garnkirk Farms	Pre-construction; on hold	Yes - Automated	Yes - Automated
	10	Gateway 270	Complete (2003)	No	No
	11	Gateway 270 Lot 7	Complete (2005)	No	No
	12	Gateway 270 West	Complete (2004)	No	Yes - Automated; existing pond outfall
	13	Gateway Commons	During Construction	Yes - Automated	Yes - Automated
	14	Greenway Village	During Construction; nearing post-construction for Phases I and II	Yes - Grab&Auto * (2 structures)	Yes - Automated; 2 structures
	15	Highlands at Clarksburg	During Construction; nearing post construction i	Yes - Grab	Yes - Automated
	16	Martens [a]	During Construction; nearing post	Yes - Grab	Yes - Automated
	17	Parkside	During Construction (post construction in 2009)	Yes - Grab	No - Not required; Temperature only
	18	Running Brook Acres	Post Construction	Yes - Grab	Yes - Automated *
	19	Stringtown Road Extension	During Construction	Yes - Automated	Yes - Automated

	20	Summerfield Crossing	During Construction; nearing post construction (late 2009/early 2010)	No - Required but not sampled	Yes - Automated
	21	Tapestry	Pre-construction; on hold	Yes - Automated	Yes - Automated
	22	Timbercreek	Completed (2008)	No	No
	23	Woodcrest	During Construction	Yes-Grab & Auto*	Yes - Automated
Paint Branch	24	Briarcliff Manor West	Complete (2006)	No	No
	25	Briarcliff Meadows North & South	During Construction (post construction in 2009)	No	Yes - Automated; 2 structures
	26	Briggs Chaney Rd. / US 29 Interchange	Complete (2008)	Yes - Grab; outfall only	Yes - Grab; outfall only
	27	Cloverly Safeway	Complete (2008)	No	Yes - Automated
	28	Fairland Community Center	Complete (2003)	No	No
	29	Fairland Gardens	Complete (2000)	No	No
	30	Forest Ridge [c]	Post Construction	Yes - Grab	No
	31	Hunt Lions Den	Post Construction	No	No
	32	Parr's Ridge [d]	Complete (2005)	No	No
	33	Snider's Estates	Complete (2008)	Yes - Grab	Yes - Flow only
Piney Branch	34	Boverman	Complete (2004)	No	No
	35	Bruck	Complete (2003)	No	No
	36	Cavanaugh	Complete (2003)	No	No
	37	Peters Property	Complete (2004)	No	No
	38	Shady Grove Rd.	Complete (2002)	No	No
	39	Snider Property	Complete (2005)	No – stream chem. below outfall	No – stream chem. below outfall
	40	Traville	During Construction (post construction in 2009)	Yes - Grab	Yes - Automated
	41	Willow Oaks	Complete (2008)	No - Requirement dropped	Yes - Automated
Upper Rock Creek	42	Preserve at Rock Creek [e]	Pre-construction	No	Yes - Automated; 2 structures
	43	Reserve at Fair Hill [f]	During Construction	No	Yes - Automated; 3 structures

[a] Martens Property is divided into two phases, which are now called Glen at Hurley Ridge (Phase I) and the Meadows at Hurley Ridge (Phase II).

[b] Summerfield Crossing is also referred to as Linthicum Property.

[c] Forest Ridge is also known as Hunt Miles Tract or Fairland Farms

[d] Parr's Ridge was previously known as Drayton Farms

[e] The Preserve at Rock Creek was previously known as the Casey Property @ Bowie Mill.

[f] The Reserve at Fair Hill was previously known as the Freeman Property.

* Automated (flow-weighted composite) sampling required, but some grab samples have been obtained instead.

Table TA-3.1. (continued). 2008 SPA projects with monitoring requirements. Numbers beneath headings indicate the number of stations monitored for the specified parameter.

SPA	No.	Project Name	Other Monitoring Requirements										
			GW[a] Lvl.	GW Chem	Stream WQ[b]	Discrete Stream Flow	Cont-inuous Flow	Cross Sections	Embedded-ness	Stream Profile	Temperature	Photo	Rain
Clarksburg	1	All Souls Cemetery						2			1		
	2	Cabin Branch	5	5	1			10			2		
	3	Catawba Manor	1										
	4	Clarksburg Detention Center (Jail)	3	3			1				1		1
	5	Clarksburg Ridge											
	6	Clarksburg Town Center			3		1				3		1
	7	Clarksburg Village (w/Greenway Trail)	18	9	1	6	2	10	6		7		1
	8	Eastside	1					3		1		1	1
	9	Garnkirk Farms	2										
	10	Gateway 270									4		
	11	Gateway 270 Lot 7										1	
	12	Gateway 270 West											
	13	Gateway Commons	3				1	3					1
	14	Greenway Village	7		1	4	1	4	4		1		
	15	Highlands at Clarksburg	5						1		2	1	
	16	Martens	4								2		
	17	Parkside	3								1	1	
	18	Running Brook Acres							1				
	19	Stringtown Road Extension											
	20	Summerfield Crossing	5		1	1			2		5		
	21	Tapestry	2					3					
	22	Timbercreek	2								2		
	23	Woodcrest	4	4									
Paint Branch	24	Briarcliff Manor West	1				1	1	2		3		
	25	Briarcliff Meadows North & South	4	4									
	26	Briggs Chaney Rd. / US 29 Interchange											

	27	Cloverly Safeway									1		
	28	Fairland Community Center	2								3	1	
	29	Fairland Gardens					1						
	30	Forest Ridge	4					3	1		2	1	1
	31	Hunt Lions Den	3					5	1		2		
	32	Parr's Ridge	1										
	33	Snider's Estates											
Piney Branch	34	Boverman	1	1					1		1		
	35	Bruck							1		2		
	36	Cavanaugh	2						1		3		
	37	Peters Property					1		2		2	1	
	38	Shady Grove Rd.							4				
	39	Snider Property			1							1	
	40	Traville	3				1	4	1		2		
	41	Willow Oaks											
Upper Rock Creek	42	Preserve at Rock Creek	4	4				3		3			
	43	Reserve at Fair Hill	4	4				2		2			1

[a] GW = Groundwater
[b] WQ = Water Quality; also known as "instream chemistry" or "surface water chemistry".

Table TA-3.2. Updates and modifications to SPA BMP project monitoring requirements.

SPA	Project	Parameter	Reason	Comment
Clarksburg	Catawba Manor	GW Level	Sampling not completed as specified	
Clarksburg	Clarksburg Detention Center	SWM BMP sampling	Discontinued	Requirement dropped
Clarksburg	Clarksburg Town Center	GW Level	Wells were never installed	To pick up additional post-construction monitoring of SWM BMPs
Clarksburg	Summerfield Crossing	S&EC grab sampling	Sampling not completed as specified	To pick up additional post-construction monitoring of SWM BMPs
Clarksburg	Summerfield Crossing	GW Level	Reduction from 5 wells to 3	2 wells abandoned
Paint Branch	Briarcliff Manor West	Continuous flow	Staff plate causing stream bank erosion	Monitoring discontinued; Requirement dropped
Paint Branch	Fairland Gardens	Continuous flow	Equipment failure and lack of data	Monitoring discontinued
Piney Branch	Traville	Stream WQ	Sampling not completed as specified	To pick up additional post-construction monitoring of SWM BMPs
Piney Branch	Willow Oaks	S&EC grab sampling	Structure deemed unsampleable	Requirement dropped; small property so no alternates available

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TA-3.2 Water Quality Monitoring

Completed projects and monitoring dates

Monitoring dates and requirements for completed projects are provided in Table TA-3.3. Table TA-3.3 is also split into two parts: the first part displays years of monitoring and structural monitoring requirements; the second part lists number of stations monitored for other parameters.

Table TA-3.3. Years of monitoring and data collected for completed SPA projects.

				Structural Monitoring	
SPA	**Project Name**	**Year Monitoring Began**	**Year Monitoring Completed**	**S&EC Structure**	**SWM Structure**
Clarksburg	All Souls Cemetery	2001	**2008**	No	No
Clarksburg	Catawba Manor	1998	**2008**	No	No
Clarksburg	Clarksburg Detention Center (Jail)	1997	2003	Yes - Grab	No- requirement dropped
Clarksburg	Gateway 270	1999	2003	No	No
Clarksburg	Gateway 270 Lot 7	2003	2005	No	No
Clarksburg	Gateway 270 West	1999	2003	No	Yes - grab; existing pond outfall
Clarksburg	Timbercreek	2001	**2008**	No	No
Paint Branch	Briarcliff Manor West /Baldi	1998	2006	No	No
Paint Branch	Briggs Chaney Rd. / US 29 Interchange	2004*	**2008**	Yes - Grab; outfall only	Yes - Grab; outfall only
Paint Branch	Cloverly Safeway	1998	**2008**	No	Yes - Automated
Paint Branch	Fairland Community Center	1998	2003	No	No
Paint Branch	Fairland Gardens	1997	2000	No	No
Paint Branch	Parr's Ridge (Drayton Farms)	1997	2005	No	No
Paint Branch	Snider's Estates	2004*	**2008**	Yes - Grab	Yes - flow only
Piney Branch	Boverman	1998	2004	No	No
Piney Branch	Bruck	1998	2003	No	No
Piney Branch	Cavanaugh	1998	2003	No	No

Piney Branch	Peters Property	1998	2004	No	No
Piney Branch	Shady Grove Rd.	1997	2002	No	No
Piney Branch	Snider Property	2000	2005	Yes - Grab; outfall only	Yes - Grab; outfall only
Piney Branch	Willow Oaks	2005**	**2008**	No - Requirement Dropped	Yes - Automated

* - Preconstruction monitoring was not required as part of the monitoring plan. The first sample was collected in 2004 as part of during construction monitoring.

** - Preconstruction monitoring was not required as part of the monitoring plan. The requirement to sample TSS during construction was also dropped. The first sample was collected in 2005 as part of post construction monitoring.

Table 3.3. (continued). Years of monitoring and data collected for completed SPA projects. Numbers beneath headings indicate the number of stations monitored for the specified parameter.

		Other Monitoring Requirements										
SPA	Project Name	GW[a] Lvl.	GW[a] Chem	Stream WQ[b]	Discrete Stream Flow	Cont-inuous Stream Flow	Cross Section	Embedded-ness	Stream Profile	Temp-erature	Photo	Rain
Clarksburg	All Souls Cemetery						2			1		
Clarksburg	Catawba Manor	1										
Clarksburg	Clarksburg Detention Center (Jail)	3	3			1				1		1
Clarksburg	Gateway 270									4		
Clarksburg	Gateway 270 Lot 7										1	
Clarksburg	Gateway 270 West											
Clarksburg	Timbercreek	2								2		
Paint Branch	Briarcliff Manor West /Baldi	1				1	1	2		3		
Paint Branch	Briggs Chaney Rd / US 29 Interchange											
Paint Branch	Cloverly Safeway									1		
Paint Branch	Fairland Community Center	2								3	1	
Paint Branch	Fairland Gardens					1						
Paint Branch	Parr's Ridge (Drayton Farms)	1										
Paint Branch	Snider's Estates											
Piney Branch	Boverman	1	1					1		1		
Piney Branch	Bruck							1		2		
Piney Branch	Cavanaugh	2						1		3		
Piney Branch	Peters Property					1		2		2	1	
Piney Branch	Shady Grove Rd.							4				
Piney Branch	Snider Property			1							1	
Piney Branch	Willow Oaks											

[a] GW = Groundwater; [b] WQ = Water Quality; also known as "instream chemistry".

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TA-3.2.1 Stream Temperature

Stream water temperature is a very important factor in maintaining the biological health of streams. SPA BMP design features that help minimize temperature impacts include: 1) requiring enhanced stream buffers and reforestation, 2) minimizing imperviousness, 3) using dry ponds for runoff quantity control to avoid standing pools that soak up excessive heat, 4) promoting infiltration using roadside swales and other infiltration structures, and 5) using sand filters and biofiltration cells which cool warm water as it filters through sand and soil.

Stream temperature is logged continuously from June 1 through September 30 at a minimum of 24-minute intervals. It is monitored before development through the post-construction period to evaluate if BMPs meet performance goals by mitigating thermal impacts.

TA-3.2.2 Embeddedness

Embeddedness is monitored to evaluate the amount of sediment covering the stream bottom. SPA BMP monitoring of embeddedness documents existing instream fine sediment loads in riffle habitats and records changes in these fine sediment loads before, during, and after BMP installation. Quarterly data collection is most often required. Monitoring is in accordance with Montgomery County Department of Environmental Protection Protocols (1998).

TA-3.2.3 Groundwater Levels

Groundwater levels are monitored to determine if there are impacts to groundwater elevations and stream baseflow as a result of the development process. Furthermore, many SPA BMPs are designed to promote infiltration, so groundwater levels are often monitored upstream and downstream of the SWM facility. Discrete or continuous groundwater levels can be collected.

Timbercreek (Clarksburg SPA)

Timbercreek is an approximately 16.1-acre residential development. Two SWM facilities outfall approximately 250 and 350 feet up-gradient of Little Seneca Creek and an area of wetlands is present between the SWM outfalls and the creek. Two groundwater wells were monitored at Timbercreek to evaluate if impacts to the wetlands and baseflow of this portion of Little Seneca were mitigated. Monthly groundwater level monitoring was performed from 2001 through 2007. Two stream temperature stations were also monitored during this time period. Monitoring of pre-construction conditions occurred in 2001; post-construction monitoring commenced in 2004 and was required for three years.

An aerial image (Figure TA-3.1) and site plan of the Timbercreek development with well locations (Fig. TA-3.2) are provided. Well MW-1 is approximately 100 feet southwest

and down-gradient from SWM Facility 4. Well MW-2 is approximately 200 feet north and up-gradient from SWM Facility #6. Well details are provided in Table TA-3.4.

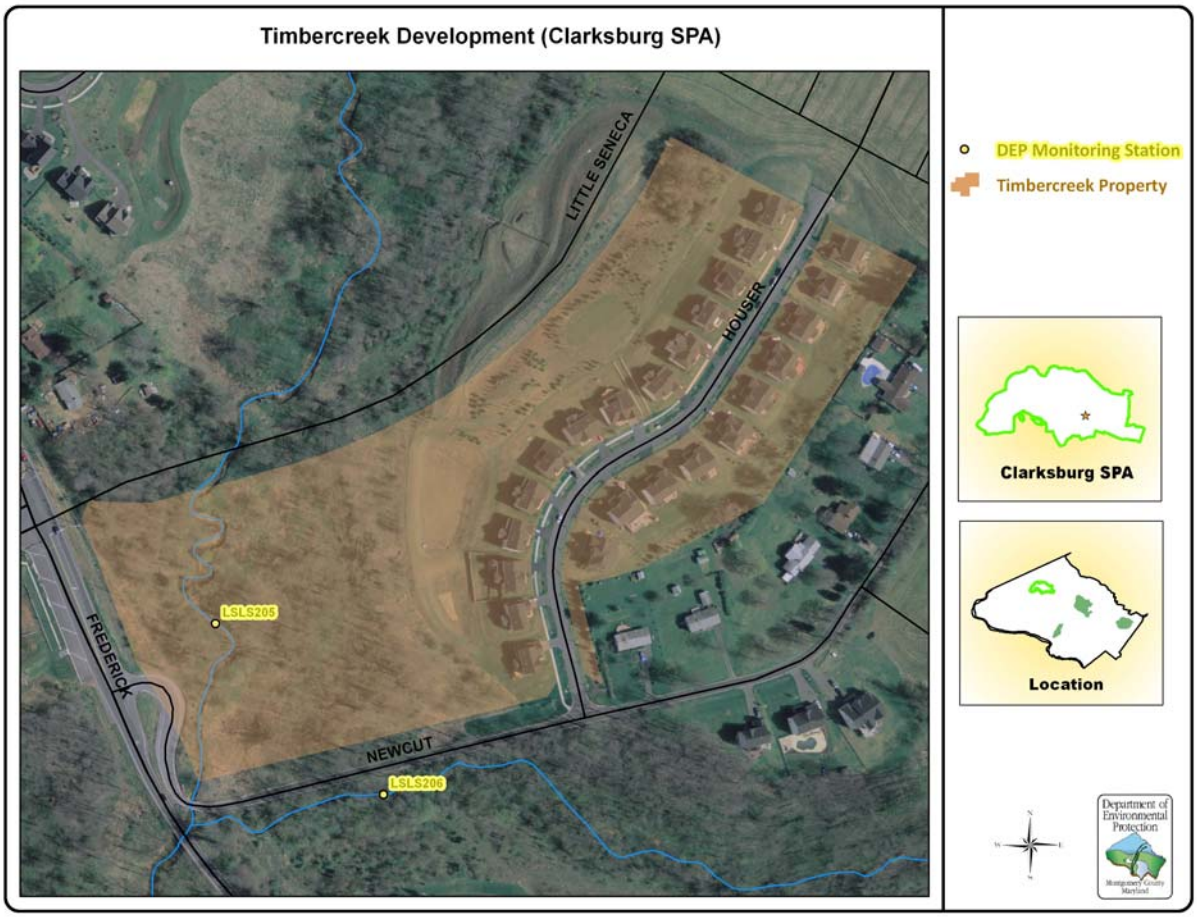

Figure TA-3.1. Timbercreek property location and 2008 aerial image.

Table TA-3.4. Details for Timbercreek groundwater monitoring wells.

Well ID	County ID	State ID	Well Depth (ft bgs)*	Casing Exposed (ft)	Main Casing Type	Date Installed	Well Location
MW-1	241914	MO-94-1836	15	1	Plastic	4/11/2001	Down-gradient / Floodplain
MW-2	241914	MO-94-1837	18.5	1.5	Plastic	4/11/2001	Up-gradient / Upland

*ft bgs = feet below ground surface

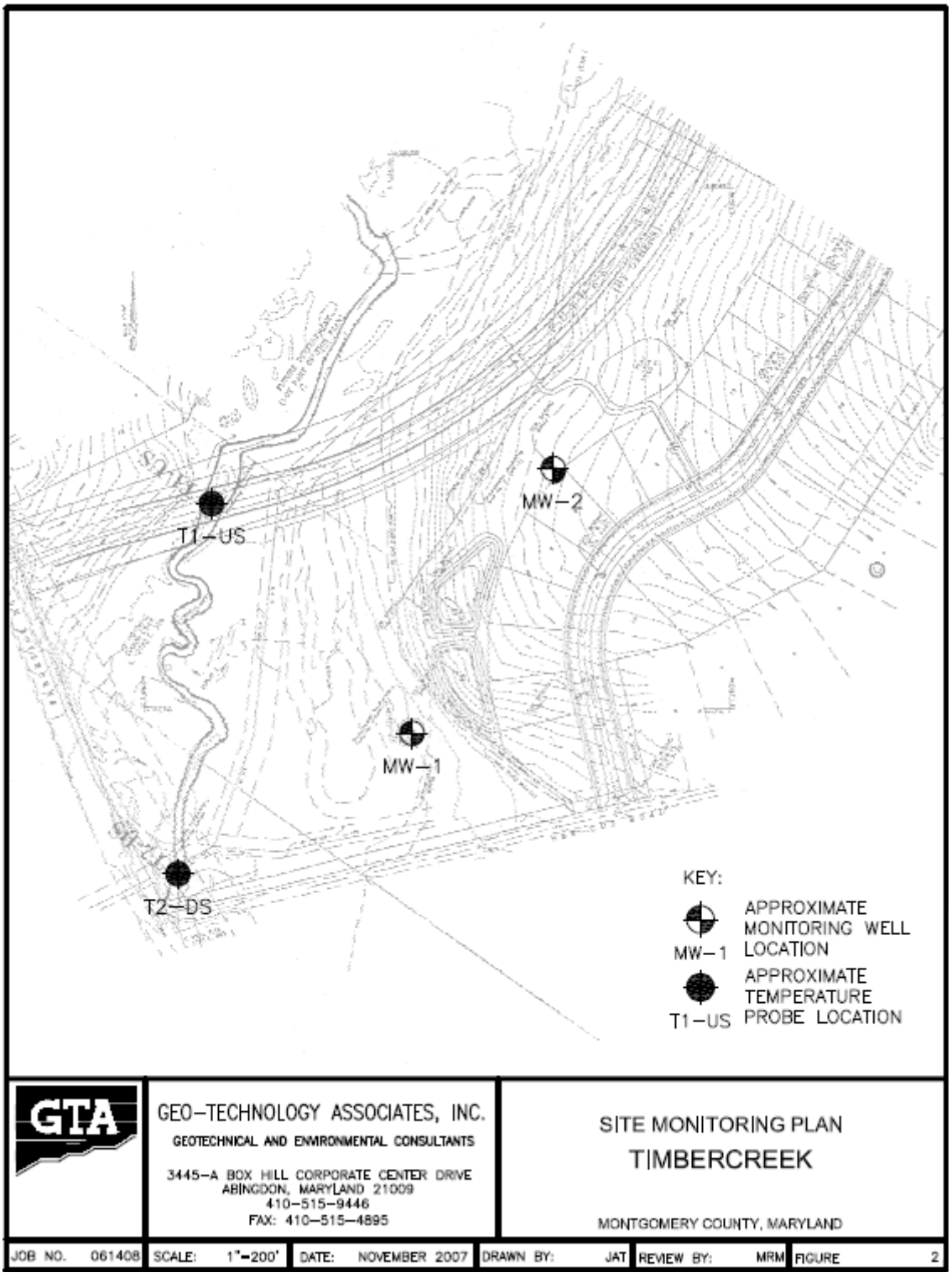

Figure TA-3.2. Timbercreek site plan and monitoring locations (GTA 2007).

TA-3.2.4 Groundwater Chemistry

In addition to effecting surface water, stormwater discharges may effect groundwater quality. The value of stormwater monitoring alone can be limited when assessing compliance with groundwater quality standards since stormwater quality is likely to change substantially while percolating through soils (Geosyntec Consultants and UWRRC 2002). Monitoring of groundwater chemistry in SPAs is often performed quarterly. Values are compared to Maryland water quality standards where values exist.

Three wells were monitored at Clarksburg Detention Center for the chemical parameters provided in Table TA-3.5. Nine samples were collected from November 1997 through September 2002. Pre-development monitoring was to last for six months, during construction monitoring until the site was stabilized and sediment control ponds were converted to stormwater management, and post-construction for three years.

Table TA-3.5. Chemical parameters, methods, and reporting limits for groundwater chemistry monitoring at the Clarksburg Detention Center (Clarksburg SPA).

Parameter	Unit	Method	Detection Limit
Ammonia	mg/L	MCAWW 350.3 [+]	0.100
Nitrate	mg/L	MCAWW 353.2	2.50
Total Kjeldahl Nitrogen	mg/L	MCAWW 351.3	0.100
Total Phosphorous	mg/L	MCAWW 365.2	0.200
Ortho-Phosphorous	mg/L	MCAWW 365.2	0.010
Specific Conductance	umhos/cm	MCAWW 120.1	1.00
pH	pH	MCAWW 150.1	0.010

[+] MCAWW - Methods for Chemical Analysis of Water and Wastes

One well was monitored twice a year at the Boverman Property in the Piney Branch SPA for groundwater chemistry (Table TA-3.6). 10 samples were collected from July 1999 through October 2003.

Table TA-3.6. Chemical parameters, methods, and detection limits for groundwater chemistry monitoring at the Boverman Property (Piney Branch SPA).

Parameter	Unit	Method	PQL [#]
Nitrate	mg/L	EPA 300.0	0.2
Nitrite	mg/L	EPA 300.0	0.2
Total Kjeldahl Nitrogen	mg/L	EPA 351.1	0.2
Phosphorus	mg/L	EPA 365.3	0.05

[#] Practical Quantitation Limit

TA-3.2.5 Instream Chemistry

Stream chemistry was monitored on the Snider Property at one station on Sheep's Run near the outfall of SWM pond #1. Sheep's Run intersects the property and joins the Piney Branch just downstream of the Snider Property. Pre-construction monitoring began August 2000 with construction monitoring commencing December 2000. Post-construction began January 2003 and was required for three years. Grab sample data for stream chemistry monitoring at Sheep's Run is presented in Table TA-3.7.

Table TA-3.7. Stream chemistry monitoring at Sheep's Run on the Snider Property (Piney Branch SPA).

Monitoring Period	Sample Date	TKN (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	TSS (mg/L)	Ortho-P (mg/L)	TP (mg/L)
	8/30/2000	1.6	1.2	ND*	43.0	0.9	1.0
	9/27/2000	2.6	0.6	0.1	26.0	1.0	1.4
Pre	10/11/2000	1.4	4.5	ND*	6.0	0.6	2.0
	5/8/2001	2.4	1.1	ND*	35.0	0.2	0.7
	7/31/2001	1.0	0.9	No Sample	16.0	No Sample	0.3
	10/25/2001	1.0	1.0	No Sample	1.0	No Sample	2.1
	10/8/2002	1.1	0.3	ND*	9.0	0.7	2.2
During	11/5/2002	0.6	.03**		7.0	1.3	1.5
	5/27/2003	2.6	1.2	ND*	7.0	1.1	5.5
	10/14/2003	1.0	1.5	ND*	12.0	0.6	5.0
	6/16/2004	0.8	0.7**		17.0	ND*	ND*
	8/4/2004	ND*	0.6**		17.0	ND*	ND*
	9/21/2004	0.8	0.3**		16.0	ND*	No Sample
	6/9/2005	ND*	1.1	ND*	18.4	ND*	ND*
	8/3/2005	1.0	1.0	ND*	12.4	ND*	No Sample
Post	10/4/2005	0.5	0.7	ND*	46.4	ND*	No Sample

*Note: ND means Not Detected; results are less than the Practical Quantitation Limit (PQL).

The PQL for TKN is 0.1mg/L, for nitrate and nitrite 0.2mg/L, for ortho phosphate 0.1mg/L, and for TP 0.05mg/L.

**Note: Laboratory did not analyze sample for nitrate and nitrite separately, but rather combined them.

Additional Note: Property owner did not allow access to property for monitoring until October in 2002.

November monitoring was added for an additional data set. Access was also denied in July 2003.

Monitoring normally occurs in spring, summer, and fall of each year.

TA-3.2.6 Continuous Stream Flow

There are no technical appendix materials for this section.

TA-3.2.7 Cross Sections

Cross sections are used to document changes to the shape and area of the stream channel. Cross sections are installed and measured in accordance with Montgomery County Department of Environmental Protection BMP Monitoring Protocols (1998).

All Souls Cemetery (Clarksburg SPA)

Annual monitoring of two cross sections in Wildcat Branch (of Great Seneca Creek) downstream of the All Souls Cemetery began in 2002 and was completed in 2008. Both cross sections, as well as a temperature monitoring station, were located below (downsteam of) the BMP outfall (Fig. TA-3.3). Plots submitted by the monitoring consultant, Macris, Hendricks, and Glasscock (MHG 2009) are provided for the upstream-most cross-section (4616-4617; Fig. TA-3.4) and the farthest downstream cross-section (4612-4615; Fig. TA-3.5).

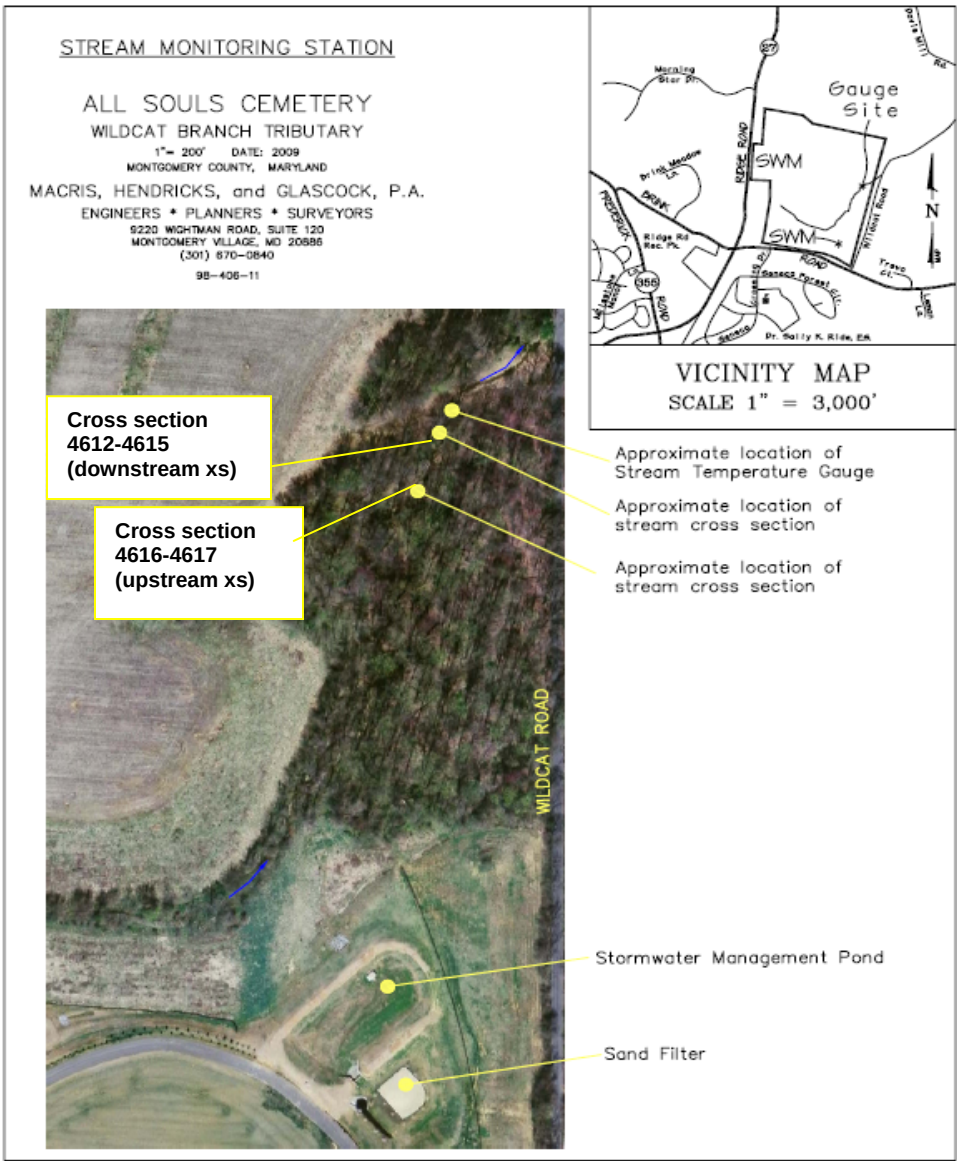

Figure TA-3.3. All Souls Cemetery site plan and monitoring locations (MHG 2009). The stream flows approximately north (denoted as blue arrows) and monitoring stations are downstream of (below) the stormwater management pond outfall.

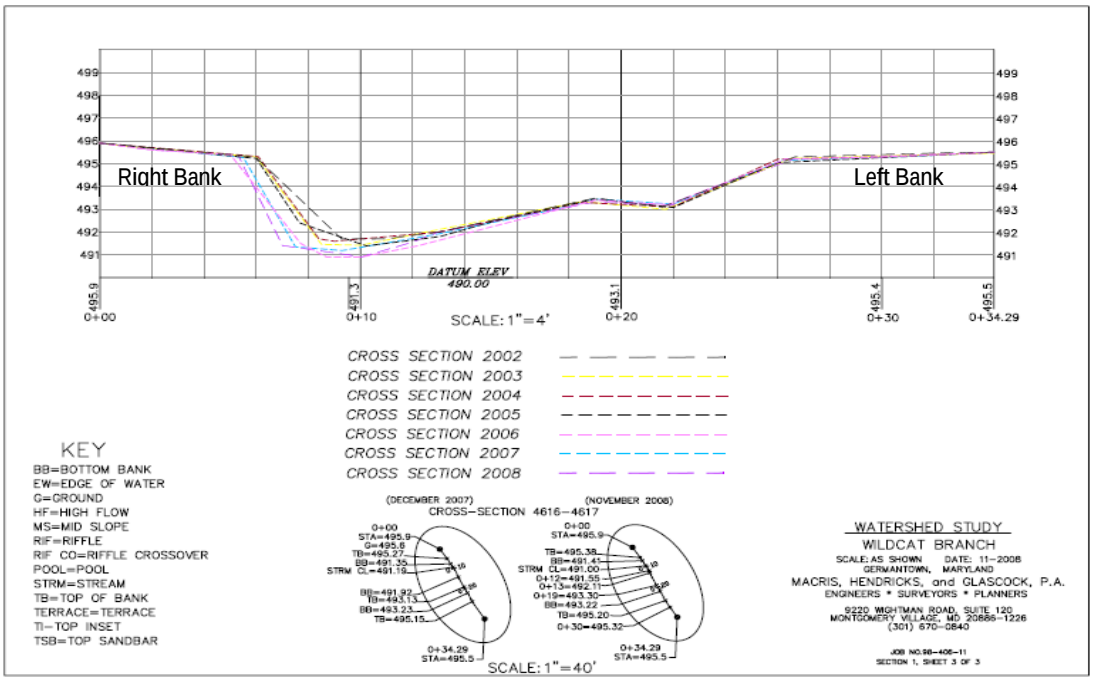

Figure TA-3.4. All Souls Cemetery cross section 4616-4617 (MHG 2009)**.**
This cross section is the farthest upstream and closest in proximity to the stormwater management pond outfall.

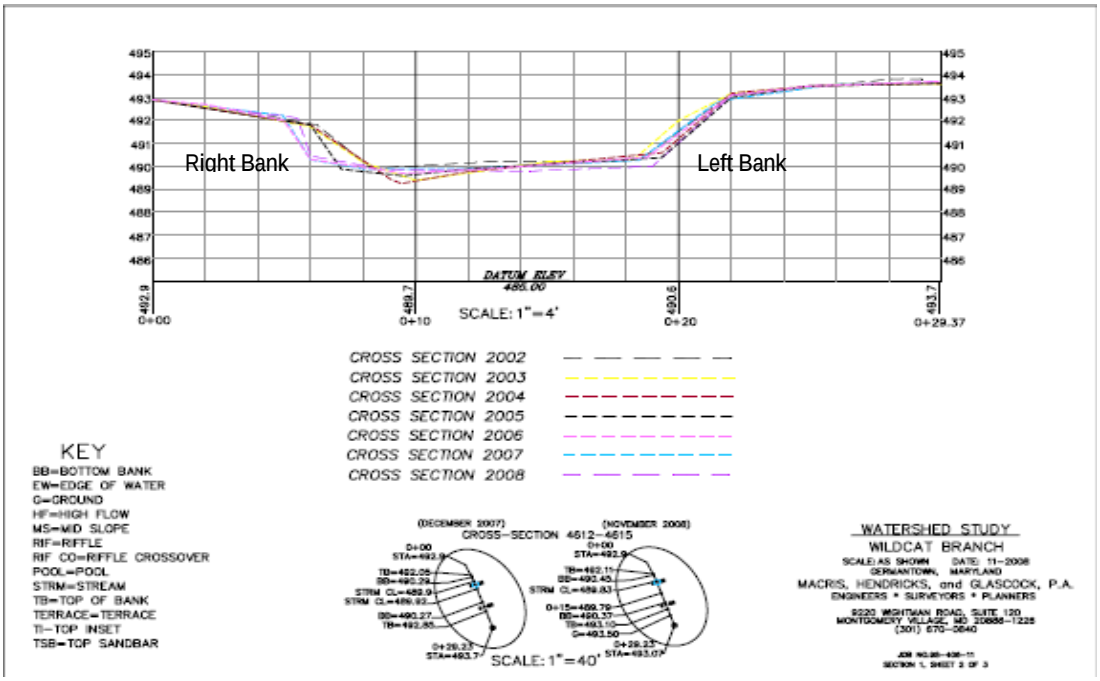

Figure TA-3.5. All Souls Cemetery cross section 4612-4615 (MHG 2009)**.**
This cross section is the farthest downstream and farthest from the stormwater management pond outfall.

TA-3.2.8 Best Management Practice Sampling

Route 29 / Briggs Chaney Road (Upper Paint Branch SPA)

A new interchange was installed at the intersection of Briggs Chaney Road and US 29 in order to relieve traffic congestion along the two roads. This project included widening Briggs Chaney Road to accommodate two additional lanes west of the intersection, as well as widening and curb modifications to Old Columbia Pike (Fig. TA-3.6). A table of construction activities is provided in Table TA-3.8.

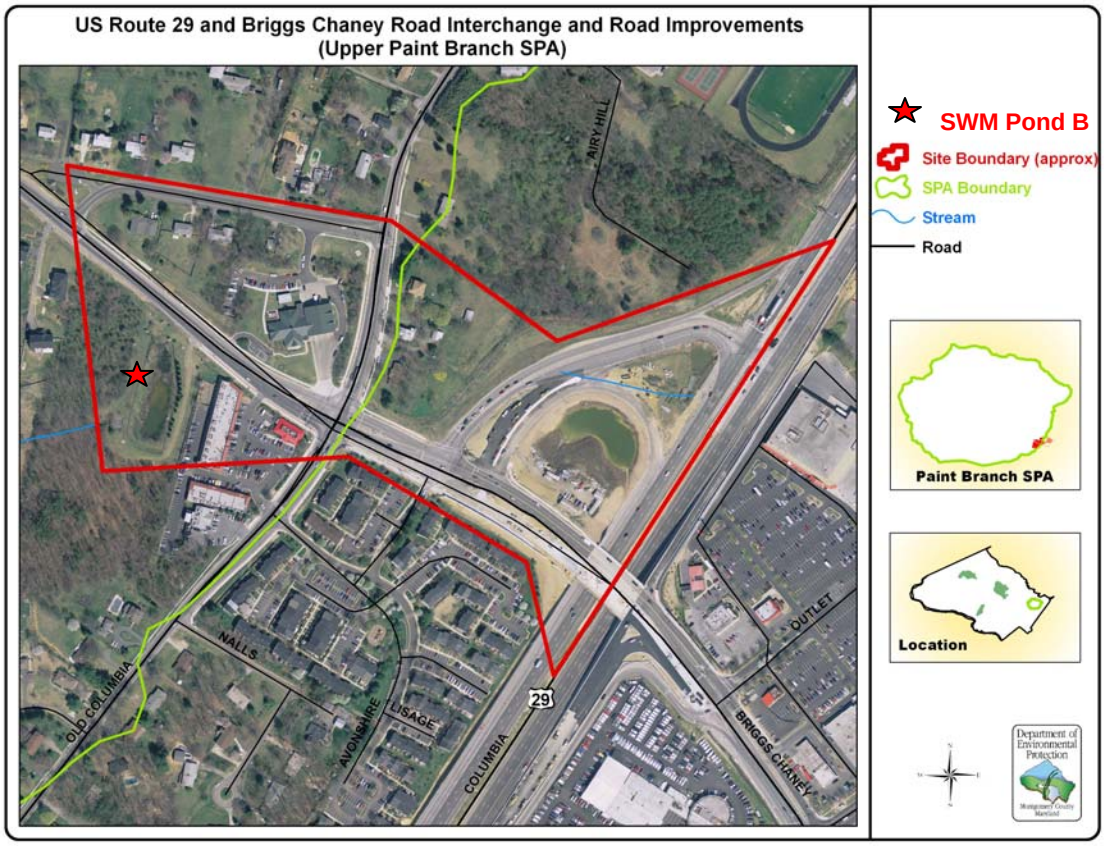

Figure TA-3.6. 2008 aerial image and approximate boundaries of US Route 29 and Briggs Chaney Road interchange and road improvements. The stormwater management pond monitored for TSS concentrations at the outfall is denoted.

TSS grab samples at the outfall of SWM Pond B (Fig. TA-3.7) were collected to monitor the structure's effectiveness while the roadway adjacent to the pond was restructured and widened. Grab samples were collected within 12 hours of the end of a rain event and at least one half hour apart. Water elevations in the outfall pipe were used to calculate flow. TSS grab sample data and flow values are provided in Table TA-3.9.

Table TA-3.8.Construction timeline for Briggs Chaney Road and US 29 interchange and road improvements (Upper Paint Branch SPA). Construction activities outside of SPA boundaries were not tracked (RKK 2009, J. Reel, personal communication)

Date	Construction Activity
June 2004	Project start up in SPA
	Installation of Sediment and Erosion Control (S&EC) *
	Some clearing
July - August 2004	Utility relocations along Old Columbia Pike and Briggs Chaney Intersection
September 2004	Installation of drainage structures along Briggs Chaney Road, within SPA
	Utility relocations within SPA (overhead and underground)
November 2004	Briggs Chaney Rd. widening begins within SPA
	Water quality swale constructed (grated, matted, and seeded)
	Drainage structures completed
	Area temporarily seeded
December 2004	Widening completed
December 2004 - November 2005	*No activity within SPA until Nov. 2005 except for seeding / stabilization*
November - December 2005	Sidewalks completed
	Utilities completed on west side of Briggs Chaney Rd.
April 2006	SWM pocket sand filter installed on north side of Briggs Chaney Rd.
April - August 2006	*No activity*
September 2006	Concrete ditch removed, replaced wisth grass swale on south side of Briggs Chaney Rd.
	Completes work within SPA except for final paving
July 2007	Entire project complete

* During construction super silt fence, inlet protection, and temporary stone outlet structures were used for S&EC.

Figure TA-3.7. SWM Pond B photos: A) Overflow structure, B) View inside the outfall pipe, C) Looking downstream of the outfall (RKK 2008).

Table TA-3.9.TSS results with flow rates and rainfall from 2003 to 2007 monitoring for Briggs Chaney Road and US 29 interchange and road improvements (Upper Paint Branch SPA).

Monitoring Period	Sampling Event	Sampling Date	TSS (mg/L)	Flow * (cfs)	Rainfall (in)
Pre-construction	1	July 23, 2003	5.0	1.01	2.15
			5.5	1.01	
			3.0	0.72	
	2	March 16, 2004	17.0	0.02	0.19
			16.0	0.01	
			17.0	0.01	
During Construction	1	July 27, 2004	2.4	0.17	0.52
			2.0	0.17	
			2.0	0.17	
	2	December 8, 2004	45.0	0.5	0.27
			42.0	0.5	
			39.0	0.5	
	3	May 25, 2005	7.0	0.03	0.3
			6.0	0.03	
			7.0	0.03	
Post Construction	1	October 25, 2007	7.5	0.24	1.6
			5.0	0.24	
			5.5	0.24	

* - Flow value calculated using water elevation in outfall pipe.

TA-3.3. Sediment and Erosion Control (S&EC) BMP Monitoring

Evaluation of BMP Efficiency Using Percent Removal

Using percent removal to evaluate BMP efficiency is a controversial topic. Two articles are most helpful regarding the topic: one that presents BMP efficiency in terms of percent removal (CWP 2007) and one that contests its use (Geosyntec Consultants and Wright Water Engineers 2007).

Copies of these documents are available online:

www.stormwater.net – Center for Watershed Protection. 2007. National pollutant removal performance database: version 3. (CWP 2007)

www.bmpdatabase.org – Frequently Asked Questions: Why does the International Stormwater BMP Database Project omit percent removal as a measure of BMP performance? (Geosyntec Consultants and Wright Water Engineers, Inc. 2007.)

Another document consulted when selecting the appropriate method to evaluate BMP efficiency can be located here:

http://www.bmpdatabase.org/docs/Urban%20Stormwater%20BMP%20Performance%20Monitoring.pdf – Urban Stormwater BMP Performance Monitoring: A Guidance Manual for Meeting the NationalStormwater BMP Database Requirements (Geosyntec Consultants and UWRRC 2002).

Full citations are provided in the Literature Cited section at the end of this document.

TA-3.3.1. Grab Samples

113 total suspended solids (TSS) grab samples were collected and considered in efficiency analysis (Table TA-3.10). % Removal Efficiency = ([influent] - [effluent]) / [influent]).

Table TA-3.10. 2008 Total suspended solid (TSS) grab sample data used to calculate median removal efficiency. A negative removal efficiency indicates that more of a pollutant is leaving the system than is entering.

SPA	Project and Structure	Project Phase	TSS Sampling Ongoing?	Sample Date	Inlet Conc. (average; (mg/L))	Outfall TSS Conc. (mg/L)	TSS removal efficiency (%)	Rain (in.)	Rainfall Duration (hours)
Clarksburg	Clarksburg Ridge Sed. Trap C	Post	No	4/12/2004	369	81.8	77.83%	1.26	
				7/7/2004	236	23.2	90.17%	1.16	
				8/2/2004	102	30	70.59%	0.04	
	Clarksburg Village - basin 'A'	During	No	4/1/2004	406.67	53.33	86.89%	1.45	
				7/8/2004	72		100.00%	0.61	
				9/9/2004	125		100.00%	0.52	
				9/18/2004	96.67	213.33	-120.68%	1.34	
				2/15/2005	53.33	27.33	48.75%	0.49	
				3/23/2005	357	284.67	20.26%	1.29	
				7/6/2005	95	78.33	17.54%	0.77	
				10/7/2005	25.33	146.67	-479.02%	0.99	
				10/25/2005	2	10	-400.00%	1.09	
				5/11/2006	20	33.33	-66.67%	0.91	
				6/26/2006	2.23	5.8	-160.09%	2.03	
				9/1/2006	3.27	3.17	3.16%	1.41	
				9/5/2006	7.73	18	-132.86%	1.24	
	Clarksburg Village - basin 'B'	During	No	4/1/2004	243	33.33	86.28%	1.45	
				7/8/2004	176	6	96.59%	0.61	
				9/9/2004	21.5	1.5	93.02%	0.52	
				9/18/2004	131.3333333	12.67	90.36%	1.34	
				2/15/2005	28.66666667	8.67	69.77%	0.49	
				3/23/2005	58.66666667	29.33	50.00%	1.29	
				7/6/2005	222.5	6.67	97.00%	0.77	
				10/7/2005	315.3333333			0.99	
				10/25/2005	30.66666667	42.67	-39.13%	1.09	
				5/11/2006	93.33333333	0	100.00%	0.91	
				6/26/2006	33.78333333	3.1	90.82%	2.03	
				9/1/2006	46.91666667	0.17	99.64%	1.41	
				9/5/2006	29.88333333	8.67	71.00%	1.24	
	Clarksburg Village Basin D	During	Yes	8/21/2007	10.0835	7.83	22.35%	0.93	0.95
				9/11/2007	4.335			0.36	1.98
				9/28/2007	3.13	4	-27.80%	0.6	5.08

				11/27/2007	5.8665	7.9	-34.66%	0.56	6
				4/22/2008	32.25	43.33	-34.37%	0.41	5.25
				4/29/2008	4.9985	32	-540.19%	0.47	10
				5/9/2008	2.45	1.67	31.96%	0.82	16
				5/16/2008	15.167	12.33	18.69%	0.69	15.75
	Clarksburg Village Basin F	During	Yes	8/21/2007	68.94333333	3	95.65%	0.93	0.95
				9/11/2007	10.22233333	6.67	34.78%	0.35	1.98
				9/28/2007	9.68879	3.77	61.12%	0.6	5.08
				10/26/2007	184.5889	18.23	90.12%	0.83	2
				4/22/2008	178.332	489.67	-174.58%	0.41	5.25
				4/29/2008	290.999	54.67	81.21%	0.47	5
				5/9/2008	179.4446667	22.33	87.55%	0.82	16
				5/16/2008	139.4446667	136	2.47%	0.69	15.75
	Glen at Hurley Ridge Basins 1 & 3	During	No	3/18/2004	12.6	4.6	63.49%	0.16	
				6/14/2004	15	4	73.33%	0.83	
				9/29/2004	47.25	156	-230.16%	2.05	
				12/10/2004	10.7	80	-647.66%	0.98	
				2/15/2005	8.4	41	-388.10%	0.47	
				6/23/2005	11.35	4.8	57.71%	0.35	
	Glen at Hurley Ridge Traps B1 & B2	During	No	10/25/2005	207	118	43.00%		
				4/4/2006	1020	NS			
				5/12/2006	94	73	22.34%		
				9/6/2006	54	38.4	28.89%		
				10/18/2006	14.8	8.4	43.24%		
				2/26/2007	274	18.2	93.36%	0.72	
				6/4/2007		27		0.54	
				8/21/2007	6	83	-1283.33%	0.59	
	Greenway Village Sed. Trap #5	During	No	6/29/2005	46.2	30	35.06%	0.57	
				7/8/2005	109.3333333	150	-37.20%	2.5	
				7/15/2005	30	60	-100.00%	0.68	
				10/8/2005	17.33333333	12	30.77%	1.95	
				9/5/2006	8.8	7.8	11.36%	1.4	
				9/14/2006	3.333333333	5	-50.00%	0.74	
				10/17/2006	23.83333333	46.7	-95.94%	0.88	
	Greenway Village Sed. Trap #7/7A	During	Yes*	8/20/2007	99.5	9	90.95%	1.11	
				10/26/2007	192.6666667	46	76.12%	1.57	
	Highlands at Clarksburg - Basin 3	During	Yes	9/29/2004	104.7	264	-152.23%		
				12/10/2004	203.7	266	-30.61%		
				2/15/2005	32.7	30	8.16%		
				6/23/2005	49.2	11.8	76.02%		
				9/15/2005	65				
				10/25/2005	68.7	83	-20.76%		
				4/4/2006	134	139	-3.73%	0.39	
				5/12/2006	205	106	48.29%	0.91	

				9/6/2006	17.8	96	-439.33%	1.23	
				10/18/2006	9.5	25.2	-164.34%	0.71	
				2/26/2007	27.2	34.2	-25.74%	0.69	
				6/4/2007	3	4	-33.33%	0.54	
				8/21/2007	12.7	4	68.42%	0.59	
				11/16/2007	10.7	1	90.63%	0.57	
				3/5/2008	133.3	28	79.00%		
				4/29/2008	24.3	10	58.90%		
	Parkside Cell #1 & Cell #2	Post	No	9/17/2004	250	330	-32.00%	1.34	
				9/28/2004	170	120	29.41%	1.83	
				6/30/2005	5	5	0.00%	0.58	
				7/15/2005	8	4	50.00%	0.75	
	Running Brook	Post	No	3/26/2002	23	18	21.74%	0.56	
				6/7/2002	58	12	79.31%	0.27	
				10/11/2002	100	104	-4.00%	1.6	
				2/4/2003	520	226	56.54%	0.4	
				5/16/2003	53	410	-673.58%	0.85	
				9/3/2003	8.5	8	5.88%	0.31	
	Woodcrest	During	Yes**	9/5/2006	598	922	-54.18%	1.57	
				9/14/2006	154	254	-64.94%	0.8	
				10/17/2006	222	384	-72.97%	1.1	
				8/20/2007	138	90	34.78%	1.04	
Paint Branch	Forest Ridge Cells #1 & #2	Post	No	9/3/2003	120			0.12	
				9/4/2003	400			0.37	
				9/23/2003	356	80	77.53%	2.14	
				4/1/2004	140	5	96.43%	1.45	
				4/13/2004	60	82	-36.67%	1.37	
				7/8/2004	132	8	93.94%	0.76	
				9/9/2004	136	25.3	81.40%	0.4	
				9/18/2004	230			1.21	
				2/15/2005	6	16	-166.67%	0.5	
				3/23/2005	32	158	-393.75%	2.1	
				7/8/2005	12	102	-750.00%	2.92	
	Snider Estates	Complete	No	4/12/2004	100	46	54.00%	1.25	22.75
				4/23/2004	53	13	75.47%	0.71	1.25
				5/18/2004	21	9	57.14%	1	0.75
				7/22/2004	31	7	77.42%	1.43	1.43

* Greenway Village Sediment Trap 7/7A is being monitored using flow-weighted composite sampling but grabs were collected instead.
** Construction at Woodcrest is ongoing but no monitoring was collected in 2008 due to lack of payment by the developer.

TA-3.3.2. Flow-weighted Composite TSS Sampling

Automated Sampling Results

The characteristics of the basins sampled are provided in Table TA-3.11. All sampling data produced from those basins and used in preparation of Figure 3.12 (in the main document) are provided in Table TA-3.12.

Table TA-3.11. Sediment and Erosion Control structure information for three sediment basins monitored in Clarksburg.

Project	Structure	Structure Type	Drainage Area (acres)	Capacity (CF)	Oversized?
Clarksburg Town Center	Basin 3	Two forebays & Main Cell	44.5	89,280	
	Forebay F		10.6	45,036	
	Forebay G		16.7	276,085	N/A *
Gateway Commons	Basin 2	Dual Cell	4.6	21,068	Yes
Stringtown Road Extension	Basin 3	Single Bay/Cell	12.9	58,071	Yes

* - Information not provided

Table TA-3.12. TSS sampling data for three Sediment and Erosion Control structures in Clarksburg (automated sampling).

Project and Structure	Structure Type	Sampling locations	Date of Event	Rainfall			TSS loadings (lbs)		TSS Load Removal Efficiency	Discharge (cfs)	
				Amount (in.)	Duration (hrs)	Return interval	Entering (Sum of Inlets)	Out		Inflow (combined inlets)	Outfall
Clarksburg Town Center - Basin 3 *	Two forebays & Main Cell	4 – 2 in East, 1 in West, 1 Out	4/30/2005	0.82	22.25	< 1 yr	520.7	29.4	94%	65488.4	57292.9
			5/19/2005	1.04	14.15	< 1 yr	366	43.2	88%	43992.0	35813.4
			5/23/2005	0.84	29.25	< 1 yr	146	17.5	88%	57025.0	38853
			5/11/2006	1.76	13	< 1 yr	342.1	196.7	43%	24563.4	66577.8
			6/1/2006	0.45	9	< 1 yr	1180	37.1	97%	64989.2	78096.6
			9/1/2006	1.95	31.58	< 1 yr	3.1	4.4	-44%	114413.1	114048.6
			12/22/2006	1.3	15.67	< 1 yr	108.4	14.3	87%	32710.9	16393.2
			3/15/2007	2.09	47	< 1 yr	87.2	4.3	95%	127003.4	83313.6
Gateway Commons - Basin 2	Dual Cell	3 – 1 inflow, 1 mid, 1 out	4/21/2006	1.11	40.67	< 1 yr	18	n.a **.	100%	127,646.40	n.a **.
			5/11/2006	1.76	13	< 1 yr	10.6	n.a **..	100%	37,628.40	n.a **..
			9/1/2006	1.95	31.58	< 1 yr	0.3	n.a **..	100%	21,450.60	n.a **..
			9/28/2006	0.79	5.5	< 1 yr	2.4	n.a **.	100%	6,084.60	n.a **.
			9/25/2008	1.88	62.25	< 1 yr	38.3	0.5	99%	48,152.40	492.6
			12/16/2008	0.64	19.1	< 1 yr	9.9	0.5	95%	43,015.40	1,002.70
			1/6/2009	1.5	24.92	< 1 yr	42	0.4	99%	83,768.20	906
Stringtown Rd Extension - Basin 3	Single Bay/Cell	2 – 1 in, 1 out	9/1/2006	1.95	31.58	< 1 yr	1.51	N.S.[(b)]	100%	7,852	1,402
			9/28/2006	0.79	5.5	< 1 yr	7.87	N.S.[(b)]	100%	1,612	414
			3/15/2007	2.09	47	< 1 yr	(a)	2.09	(a)	(a)	10,872
			4/11/2007	0.84	7.42	< 1 yr	1.05	0.12	88.80%	2,917	655
			6/28/2007	0.79	0.67	< 1 yr	75.48	0.03	99.96%	3,457	269
			12/2/2007	0.57	8.33	< 1 yr	0.38	0.02	94.50%	1,843	811

* Twelve storms total; only storms with valid flows & calculated loadings considered.
** No outflow
(a) Not calculated due to backwater in Station #1 pipe.
(b) N.S. denotes no samples taken due to low water levels in Station #2 pipe.

Sediment Basin #3 Clarksburg Town Center (Clarksburg SPA)

Monitoring requirements and the dates of monitoring for Clarksburg Town Center are provided in Table TA-3.13. The locations of monitoring stations in Clarksburg Town Center are provided in Fig. TA-3.8.

Table TA-3.13. Clarksburg Town Center monitoring.

Monitoring Requirement	Dates of Construction Monitoring		
	Pre	**During**	**Post** [(a)]
Annual stream water chemistry (baseflow and flow-weighted stormwater samples)	April 1997 – May 1998	5/2/2001 - present	n/a
Continuous flow data and stream stage		10/5/2000 - present	n/a
Instream temperature		9/28/2000 - present	n/a
Embeddedness			n/a
Cross sections		4/2005 - present	n/a
S&EC Basin (TSS)	Not required	1/2005 to present	Not required
SWM BMP Efficiency	Not required	Not required	n/a

(a) - Clarksburg Town Center is still in the construction phase and post-construction monitoring will not begin until S&EC structures are converted, as-builts are approved, and a post-construction stream monitoring bond has been posted.

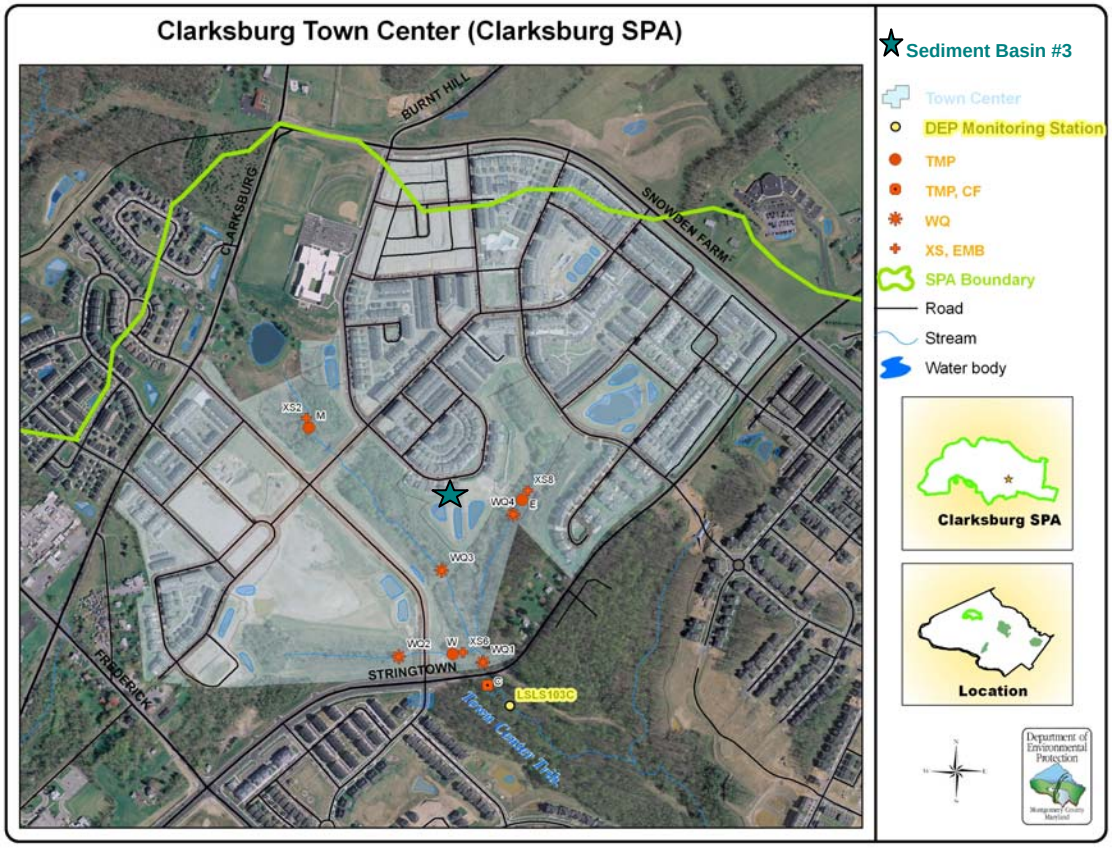

Figure TA-3.8. Clarksburg Town Center 2008 aerial and monitoring locations.

Approximate consultant monitoring stations denoted in orange: TMP = Temperature; TMP, CF = Temperature & Continuous Flow; WQ = Surface Water Quality (stream chemistry); XS, EMB = Cross Section and Embeddedness.

Sediment Basin #3 (Fig. TA-3.9) on Burdett Avenue is monitored quarterly for TSS using flow-weighted composite sampling. Complete TSS concentrations (Table TA-3.14) are provided.

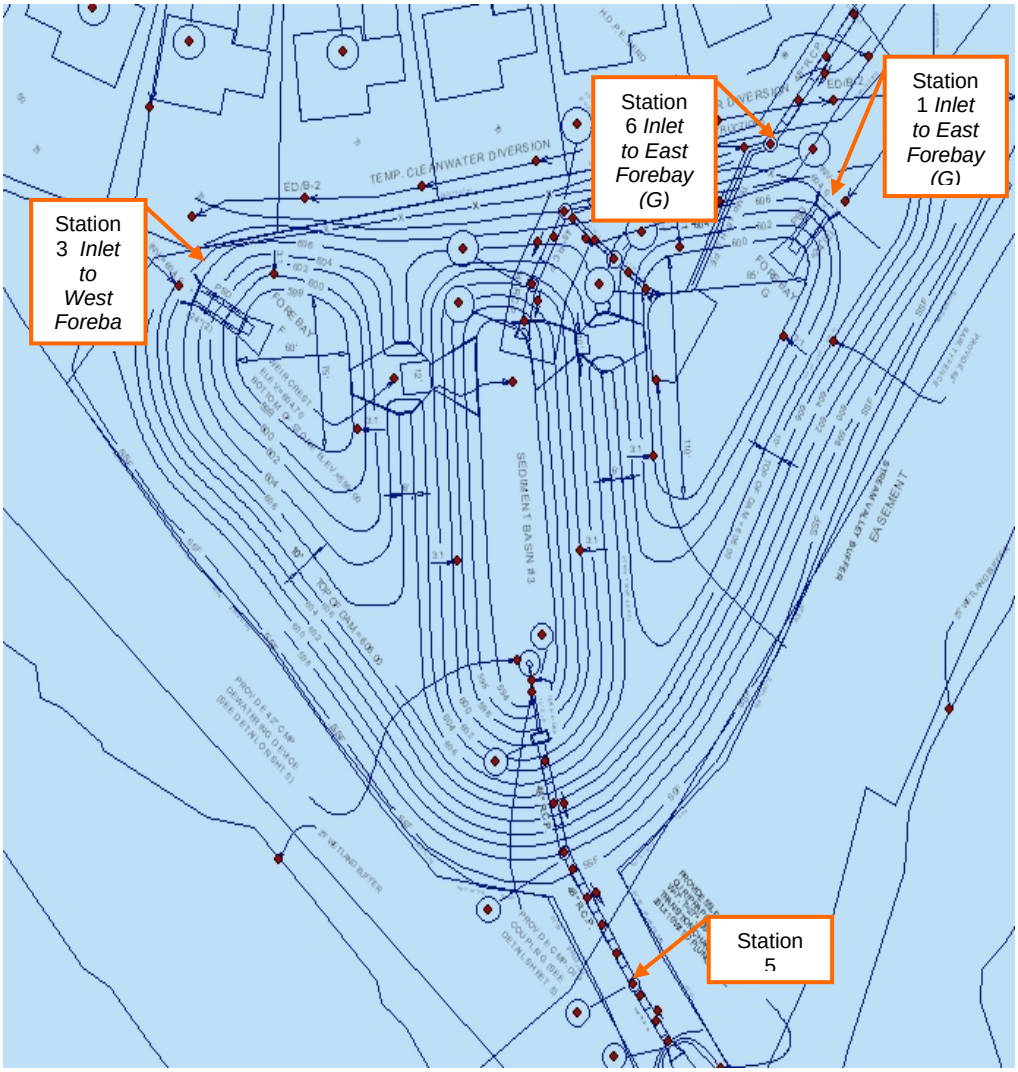

Figure TA-3.9. Plan view of Clarksburg Town Center Sediment Basin #3 (Jones 2007). Final monitoring stations (4) are indicated.

Table TA-3.14. TSS concentration results (mg/L) for flow-weighted composite sampling of Sediment Basin #3 at Clarksburg Town Center.

Storm Number	Date of Rainfall	Rainfall (inches)	Rainfall Duration (hours)	Rainfall Return Interval	TSS Concentration (mg/L)			
					Station 1	Station 3	Station 5	Station 6
					Inlet to East Forebay (Forebay G)	Inlet to West Forebay (Forebay F)	Outfall (initial round of sampling)	48" Concrete Inlet to East Forebay (G)
1	3/23/2005	2.11	14.75	< 1 yr	590	1300	420	*
2	3/27/2005	1.37	26.25	< 1 yr	1600	850	500	*
3	4/1/2005	1.93	26.00	< 1 yr	4,200	4,400	1,100	*
4	4/30/2005	0.82	22.25	< 1 yr	230	140	40	630
5	5/19/2005	1.04	14.15	< 1 yr	240	N.S	94	670
6	5/23/2005	0.84	29.25	< 1 yr	160	N.S.	35	200
7	4/21/2006	1.11	40.67	< 1 yr	200	N.S.	28	40
8	5/11/2006	1.76	13.00	< 1 yr	1800	370	230	610
9	6/1/2006	0.45	9.00	< 1 yr	3000	N.S.	37	1400
10	9/1/2006	1.95	31.58	< 1 yr	12	N.S.	3	2
11	12/22/2006	1.30	15.67	< 1 yr	120	3700	68	74
12	3/15/2007	2.09	47.00	< 1 yr	17	N.S.	4	54

* - An additional inlet to the east forebay (Forebay G) was discovered after the third monitored storm (April 1, 2005)

N.S. denotes no samples taken due to low water levels in pipe.

Sediment Basin #2 Gateway Commons (Clarksburg SPA)

Monitoring requirements and the dates of monitoring are provided in Table TA-3.15. A site plan with monitoring stations in Gateway Commons provided in Fig. TA-3.10

Table TA-3.15. Gateway Commons monitoring.

Monitoring Requirement	Monitoring dates [a]
Groundwater elevations; year-round	1/30/2003 - present
Cross sections	
Instream temperature	6/1/2003 - present
Continuous flow	2/5/2003 - present
S&EC Basin (TSS); quarterly	10/27/2005 - present; during construction only
SWM BMP Efficiency	n/a; post-construction only

(a) - Gateway Commons is still under construction and post-construction monitoring will not begin until S&EC structures are converted, as-builts are approved, and a post-construction stream monitoring bond has been posted.

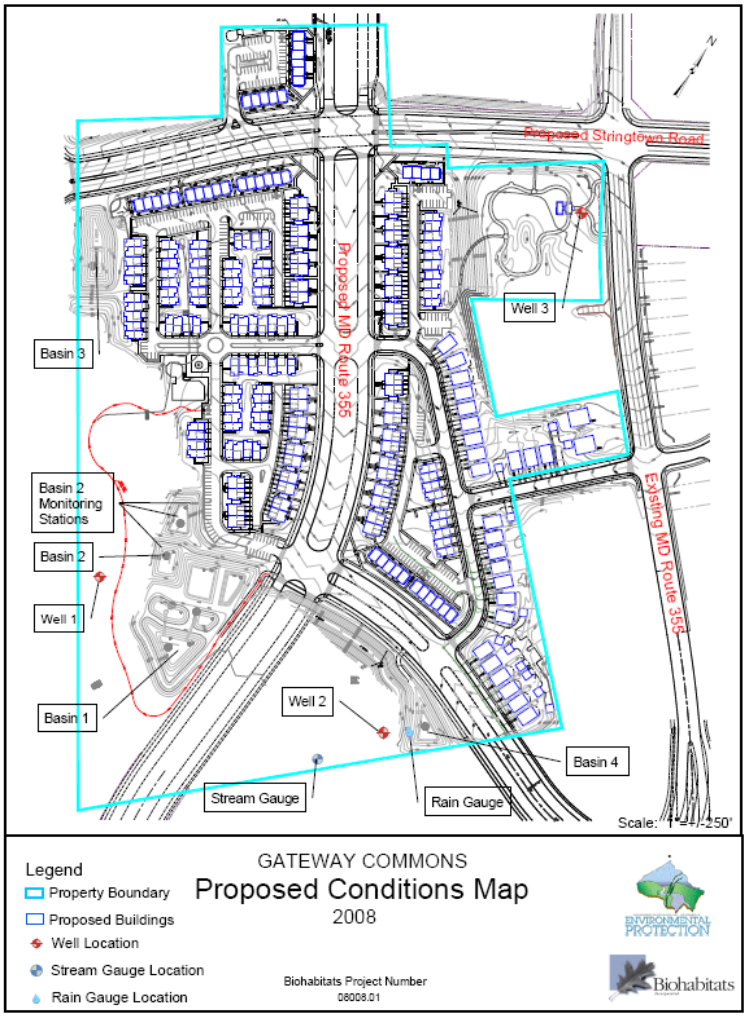

Figure TA-3.10. Gateway Commons site plan (proposed) and monitoring locations (Thompson 2008).

Sediment Basin #2 (Fig. TA-3.11) on Roberts Tavern Drive in Gateway Commons is monitored quarterly for TSS using flow-weighted composite sampling. Monitoring was conducted from April through October 2006. Construction began on February 12, 2005, but monitoring was delayed by the need to finalize the basin configuration and to direct overland flows to the basin. Construction activities ceased in March 2006 while an additional plan was reviewed.

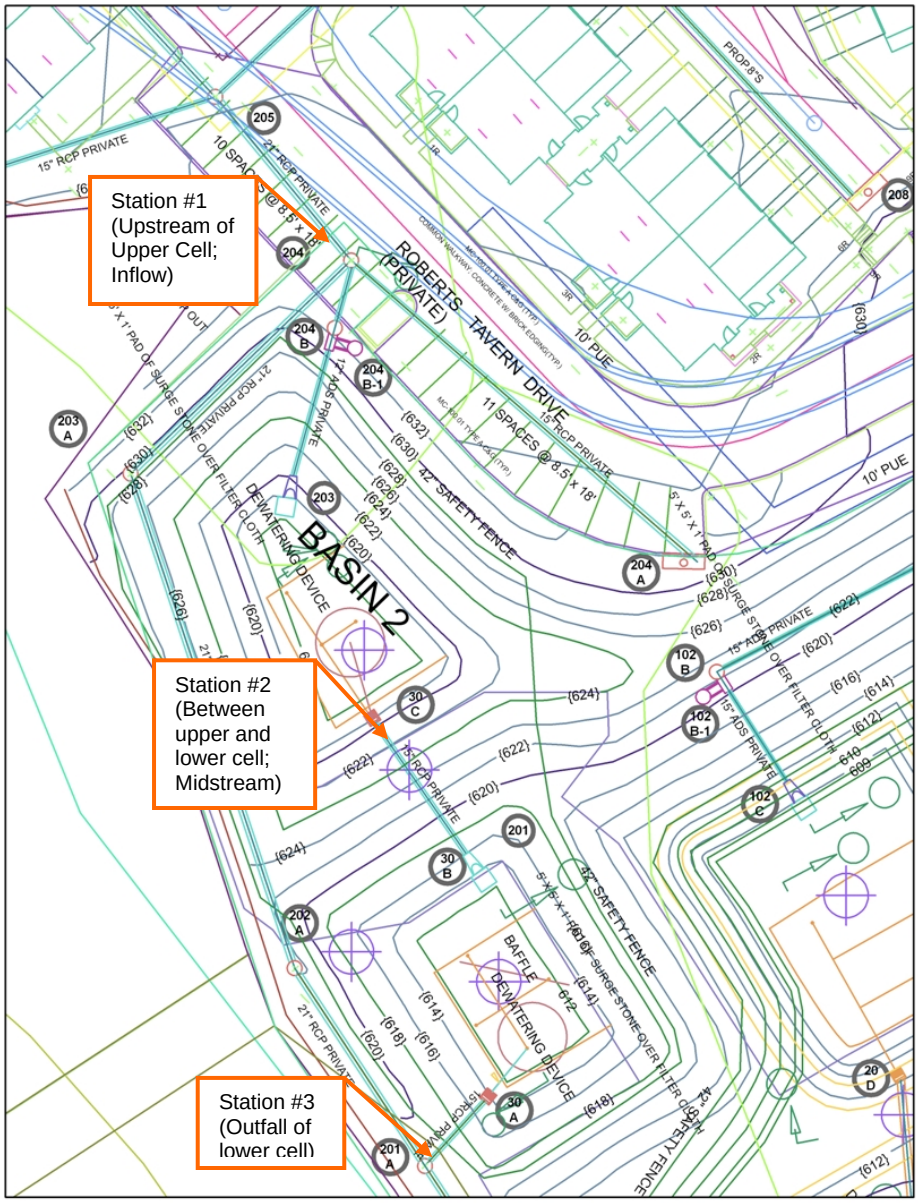

Figure TA-3.11. Plan view and sampling locations of Gateway Commons Sediment Basin #2 (Jones 2009a).

Complete storm event information and TSS concentrations, loadings, and reductions (Table TA-3.16) are provided.

Table TA-3.16. Total suspended solids (TSS) monitoring at Gateway Commons Sediment Basin #2.

Date of Event	Rainfall			TSS Concentration (mg/L)			TSS Loading (lbs)			TSS Load Reduction		Discharge Volume (CF)		
	Amount (in)	Duration (hrs)	Return Interval (yr)	Station #1 [a]	Station #2	Station #3	Station #1	Station #2	Station #3	Station #1 to Station #2	Station #1 to Station #3	Station #1	Station #2	Station #3
4/21/2006	1.11	40.67	< 1	11	57	n.a.	18	3.4	n.a.	81%	n.a.	127646.40	4598.40	n.a.
5/11/2006	1.76	13	< 1	22	19	n.a.	10.6	0.8	n.a.	92%	n.a.	37628.40	3286.50	n.a.
9/1/2006	1.95	31.58	< 1	1	n.a.	n.a.	0.3	n.a.	n.a.	100%	n.a.	21450.60	n.a.	n.a.
9/28/2006	0.79	5.5	< 1	31	n.a.	n.a.	2.4	n.a.	n.a.	100%	n.a.	6084.60	n.a.	n.a.
9/25/2008	1.88	62.25	< 1	62	150	80	38.3	9.9	0.5	74%	99%	48152.40	5161.20	492.6
12/16/2008	0.64	19.1	< 1	18	150	38	9.9	37.1	0.5	-273%	95%	43015.40	19251.20	1002.70
1/6/2009	1.50	24.92	< 1	39	34	36	42	2	0.4	95%	99%	83768.20	4544.60	906
mean	1.38	28.15		26	82	51	17.4	10.6	0.5	38% [c]	98%	52535.14	7368.38	800.43

[a] Station locations provided in figure TA-3.11.

[b] n.a. not applicable (no samples taken due to low water levels in pipe)

[c] TSS load reduction of first cell increases to 90% when storm even on 12/16/2008 is excluded.

According to Jones (2009a):

"A paired Student's t-test on the compiled data from seven storms showed that the reduction in loading that occurred between Station #1 and Station #2 was not statistically significant (P=0.28), probably because of the results of the December 2008 storm. When comparing Station #1 and Station #3 loading data, the Student's paired t-test showed a significant (P=0.03) reduction."

Paired Student's T-Test

This statistical analysis is used to compare a set of quantitative data where the data points are related and paired – in this case **loadings in vs loadings out** during the same storm event.

Stringtown Rd. Extension Sediment Basin #3 (Clarksburg SPA)

No monitoring other than TSS during construction and pollutant removal efficiency post construction is required at this property. An aerial image of the site is provided (Fig. TA-3.12)

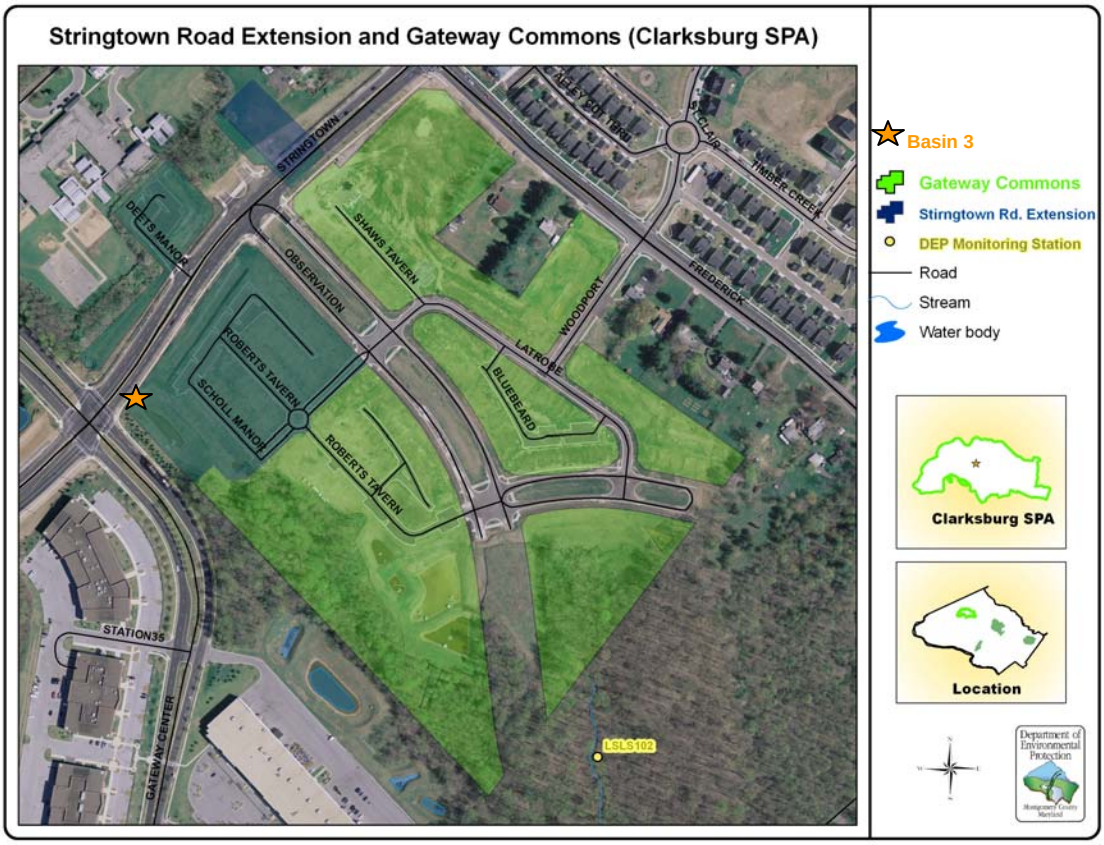

Figure TA-3.12. 2008 aerial image of Stringtown Road Extension and Gateway Commons.

Storm event TSS concentrations and loadings are provided in Table TA-3.17. The site plan and sampling locations for Stringtown Rd. Extension Sediment Basin #3 are provided (Fig. TA-3.13).

TSS sampling at the inlet and the outfall of Sediment Basin #3 took place from September 2006 through December 2007. Construction on the Stringtown Road Extension has been completed since November 2006, but Basin #3 will not be converted to SWM until construction is completed at Gateway Commons since the two properties both drain to this basin.

Table TA-3.17. Total suspended solids monitoring at Stringtown Rd. Extension Sediment Basin #3.

Date of Event	Rainfall			TSS (mg/L)		TSS loading (lbs)		TSS Load Reduction	Discharge (CF)	
	Total (in.)	Duration (hrs)	Return Interval (yr)	Station #1	Station #2	Station #1	Station #2	Station #1 to Station #2	Station #1	Station #2
9/1/2006	1.95	31.58	< 1	15	N.S.[b]	1.51	N.S.[b]	100%	7,852	1,402
9/28/2006	0.79	5.5	< 1	380	N.S.[b]	7.87	N.S.[b]	100%	1,612	414
3/15/2007	2.09	47	< 1	23	15	(a)	2.09	(a)	(a)	10,872
4/11/2007	0.84	7.42	< 1	28	14	1.05	0.12	88.80%	2,917	655
6/28/2007	0.79	0.67	< 1	1700	9	75.48	0.03	99.96%	3,457	269
12/2/2007	0.57	8.33	< 1	16	2	0.38	0.02	94.50%	1,843	811
mean	1.17	16.75		360	10	17.26	0.57	97%	3536	2404

(a) Not calculated due to backwater in Station #1 pipe

(b) N.S. denotes no samples taken due to low water levels in Station #2 pipe.

According to Jones (2008a):

"A paired Student's t-test on the compiled data from five of the six storms showed that the reduction in loading that occurred between Station #1 and Station #2 was not statistically significant (P=0.30), most likely because of the small number of samples."

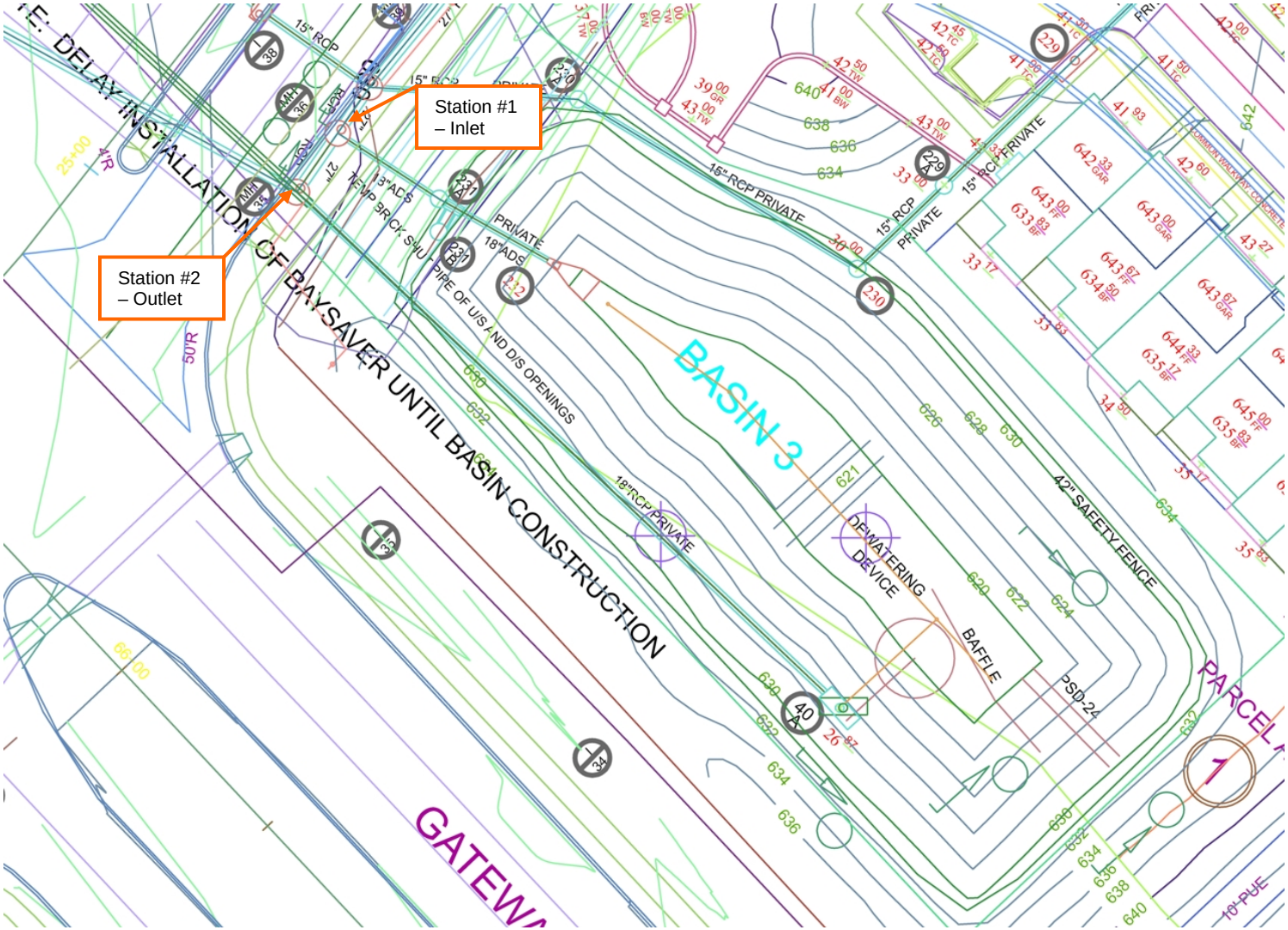

Figure TA-3.13. Plan view and sampling locations of Stringtown Rd. Extension Sediment Basin #3 (Jones 2008a).

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TA-3.4. Stormwater Management (SWM) BMP Monitoring

Stormwater Treatment Trains in SPAs

Various BMPs are combined in series or as part of a treatment train in order to maximize pollutant reduction and improve stormwater treatment performance. Redundant controls (treatment trains) are required for stormwater quality control in SPAs (Fig. TA-3.14).

TA-3.4.1 Surface Sand Filter

Background

For more information on surface sand filters, please consult the following suggested materials:

http://permittingservices.montgomerycountymd.gov/permitting/docs/rev2005MCSF.pdf - Montgomery County Sand Filter (MC DPS 2007)

http://www.epa.gov/owm/mtb/sandfltr.pdf – Fact Sheet Sand Filters (US EPA 1999a)

http://www.epa.gov/nrmrl/pubs/600r04184/600r04184.pdf - The Use of Best Management Practices (BMPs) in Urban Watersheds (US EPA 2004).

http://www.cwp.org/Resource_Library/Center_Docs/PWP/ELC_PWP105.pdf – Developments in Sand Filter Technology to Treat Stormwater Runoff. (T.R.S. 2002)

http://www.fhwa.dot.gov/environment/ultraurb/3fs8.htm –Fact Sheet – Surface Sand Filters (Shoemaker et al. 2002a)

http://www.metrocouncil.org/environment/Watershed/BMP/CH3_STFiltSurfSand.pdf – Chapter 3: Best Management Practices: Surface Sand Filters (Metropolitan Council & Barr Engineering Co. 2001)

Full citations are provided in the Literature Cited section at the end of this document.

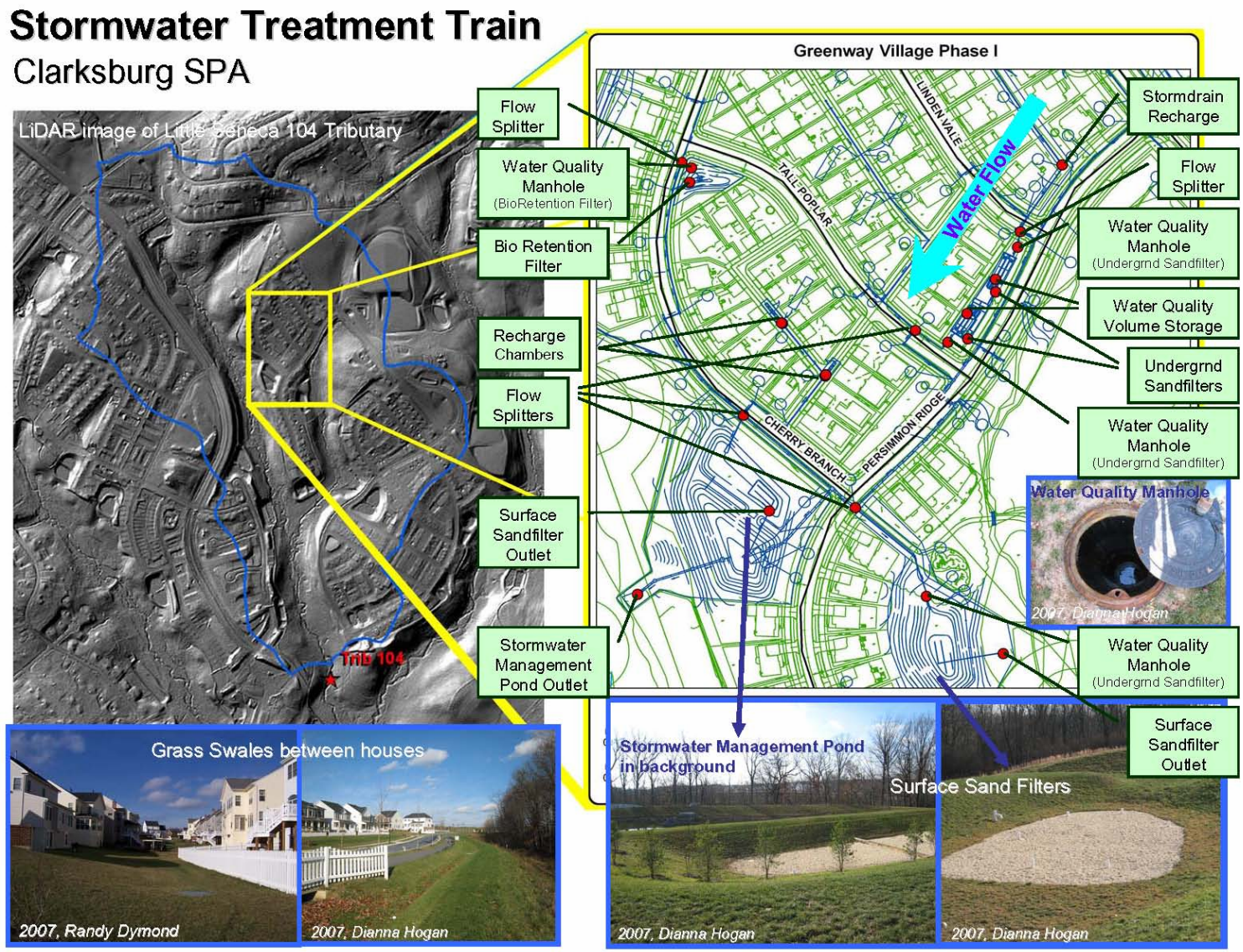

Figure TA-3.14. Enlargement of a section of the 2007 LiDAR image of Greenway Village Development (Newcut Road Neighborhood) showing the redundant water quality and quantity SWM BMPs designed to mitigate imperviousness impacts.

Willow Oaks (Piney Branch SPA)

An aerial and plan view of the Willow Oaks sand filters (two in series) are provided (Figs TA-3.15 and TA-3.16). BMP pollutant removal efficiency data was collected using flow-weighted composite sampling. Table TA-3.18 lists the parameters and detection limits for the Willow Oaks SWM BMP monitoring (Jones 2008b).

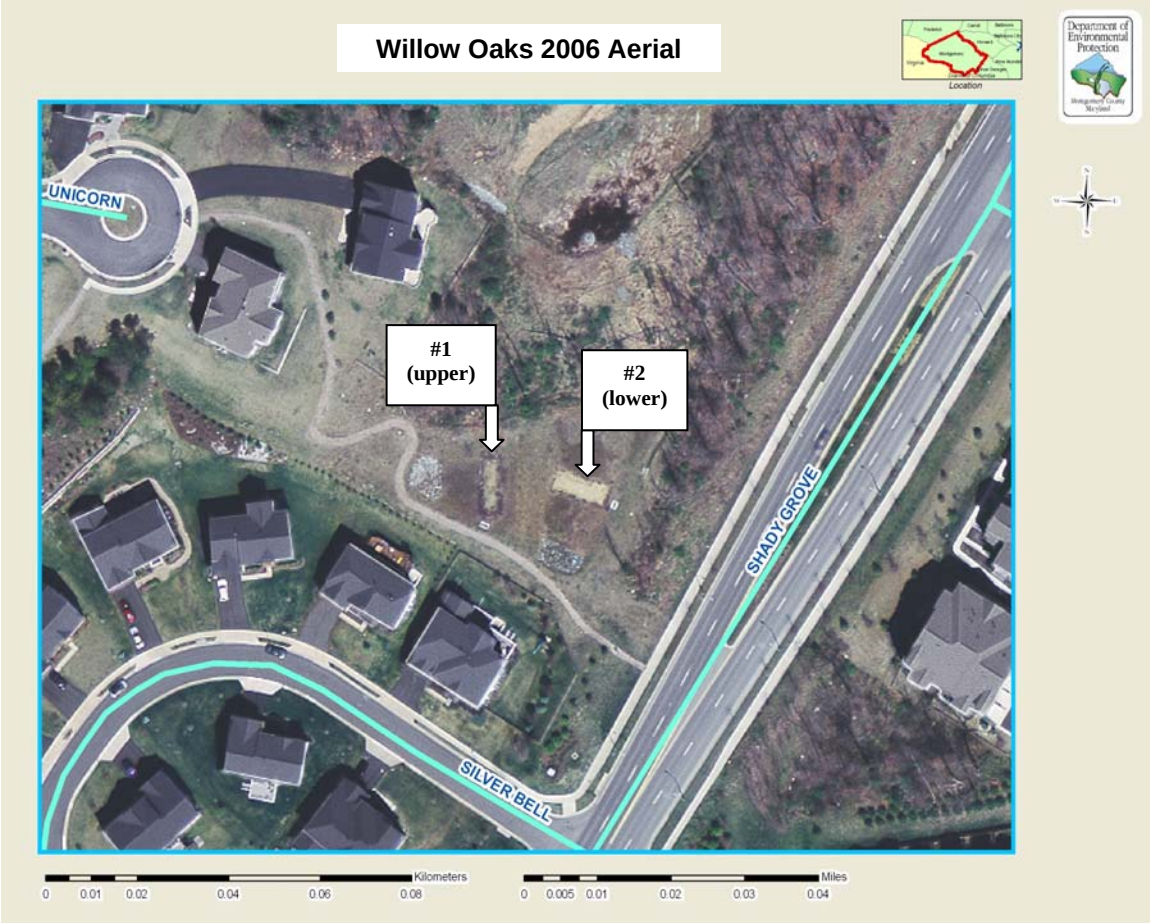

Figure TA-3.15. Aerial image of Willow Oaks sand filters.

The only other monitoring requirement at Willow Oaks was for TSS sampling during construction, but this requirement was dropped when the structure was deemed unsampleable. An alternate sediment basin could not be selected due to the relatively small development and level of disturbance.

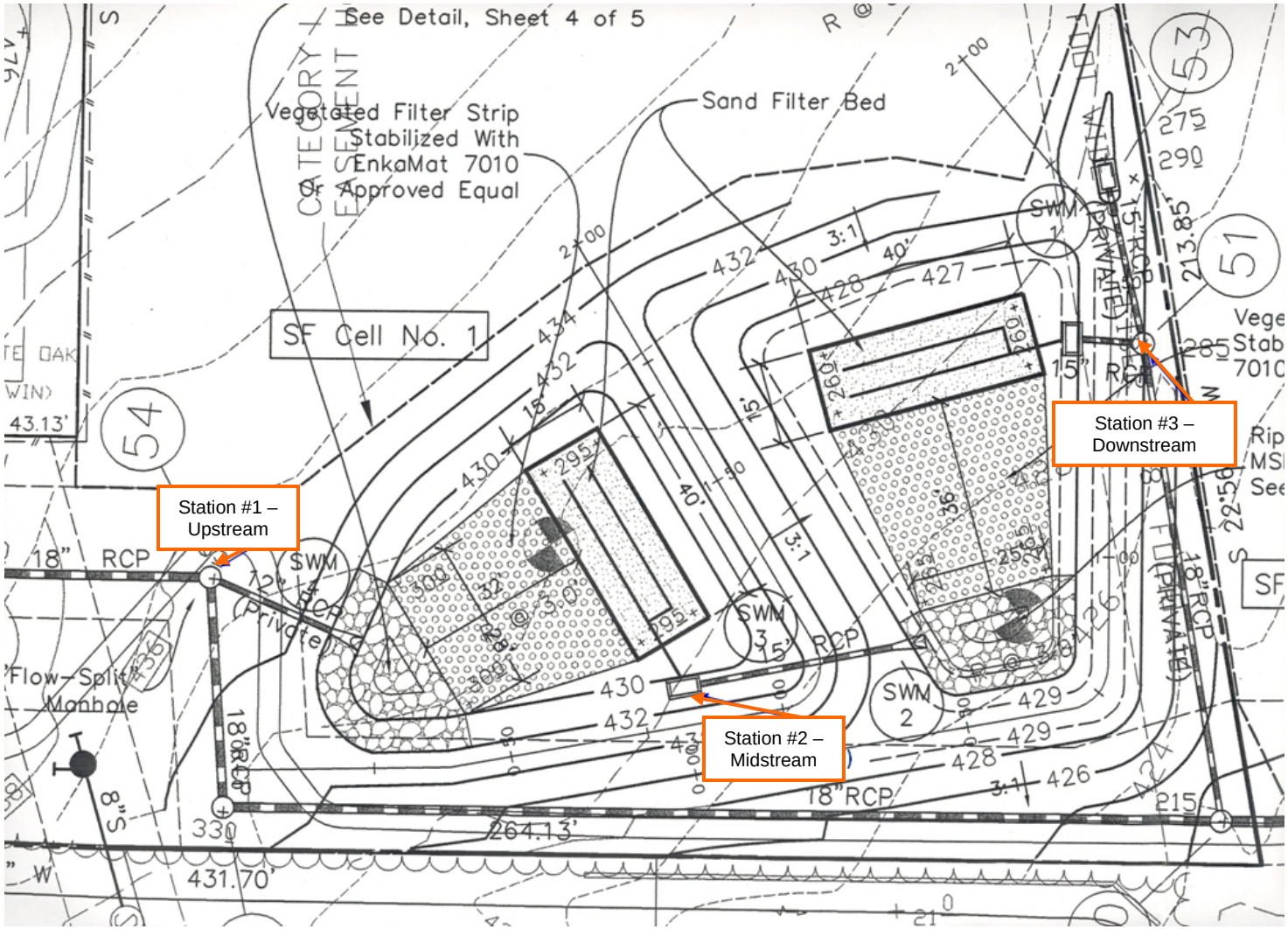

Figure TA-3.16. Plan view of Willow Oaks BMP with monitoring locations (3) denoted (Jones 2008b).

Table TA-3.18. Parameters and detection limits for Willow Oaks BMP monitoring.

Parameter	Detection Limit (mg/L)	Method	MD Freshwater Acute Criteria (mg/L)*
Cadmium	0.0005	EPA 200.8	0.002
Copper	0.002	EPA 200.8	0.013
Lead	0.002	EPA 200.8	0.065
Zinc	0.010	EPA 200.8	0.12
Nitrate	0.02	EPA 353.1& SM 4500NO3-H	None
Nitrite	0.02	EPA 353.1 & SM 4500NO3-H	None
Total Kjeldahl Nitrogen (TKN)	0.5	EPA 351.3& SM4500NH3-C	None
Total Nitrogen	0.02	EPA 353.1 & SM 4500NO3-H	None
Total Suspended Solids (TSS)	1.0	EPA 160.2 & SM 2540 D	None
Total Phosphorus	0.01	EPA 365.2 & SM 4500P-E	None
Orthophosphate	0.01	EPA 365.2 & 4500P-E	None

* Water quality criteria for metals are based on dissolved forms; water chemistry data provided are for total metal concentration.

Monitored storm events (Table TA-3.19) and concentrations and loadings of pollutants from monitored storm events are presented (Tables TA-3.20 – TA-3.22).An estimated flow value was provided for the 2/1/2008 storm event (Table TA-3.19). An equipment failure caused a loss of flow data for a period. An integration below the curve of the hydrograph (Fig.TA-3.17) at the points where the unit cut off and regained function allowed for a calculated estimate. Furthermore, the hydrograph is usually relatively flat during other monitored storms at Station 3 / the downstream station (Jones 2008b; Jones 2009, personal communication).

Table TA-3.19. Characteristics of monitored storms at the Willow Oaks sand filters.

	Storm Characteristics				Discharge Volume (m^3)		
Date of Event	Rain (in)	Rainfall Duration (hours)	Rainfall Return Interval	Preceding drying time (h)	Station #1	Station #2	Station #3
7/7/2005	2.59	14.5	1-2	42.25	5,712	6,440[(a)]	24,577[(b)]
10/24/2005	1.35	29.25	< 1	46.5	4,660	981	15,396[(b)]
1/22/2006	0.8	14.5	< 1	108.25	2,737	410	293
4/21/2006	1.51	26.75	< 1	104.5	2,649	2,984[(a)]	269
9/28/2006	0.73	4.75	< 1	98.5	636	34	1,497[(b)]
10/17/2006	0.74	9	< 1	116.5	1,161	73	37
11/16/2006	1.6	7.75	< 1	72	3,887	8,337[(a)]	99

4/11/2007	0.72	7.25	< 1	105	723	57	85
12/15/2007	0.76	14.5	< 1	36.17	1972	117	373
2/1/2008	1.3	7.92	< 1	64.17	861	4202[(a)]	638[(c)]
3/4/2008	2.11	13.92	< 1	168.17	616	869[(a)]	228
3/7/2008	0.67	27.5	< 1	54.75	338	59	153
3/19/2008	0.56	13.83	< 1	50.67	229	40	75

[(a)] Inaccurate flow rate measurement due to ponding in weir (Station #2)

[(b)] Inaccurate flow rate measurement due to bubble line misplacement or pinching (Station #3)

[(c)] Discharge includes estimated amount

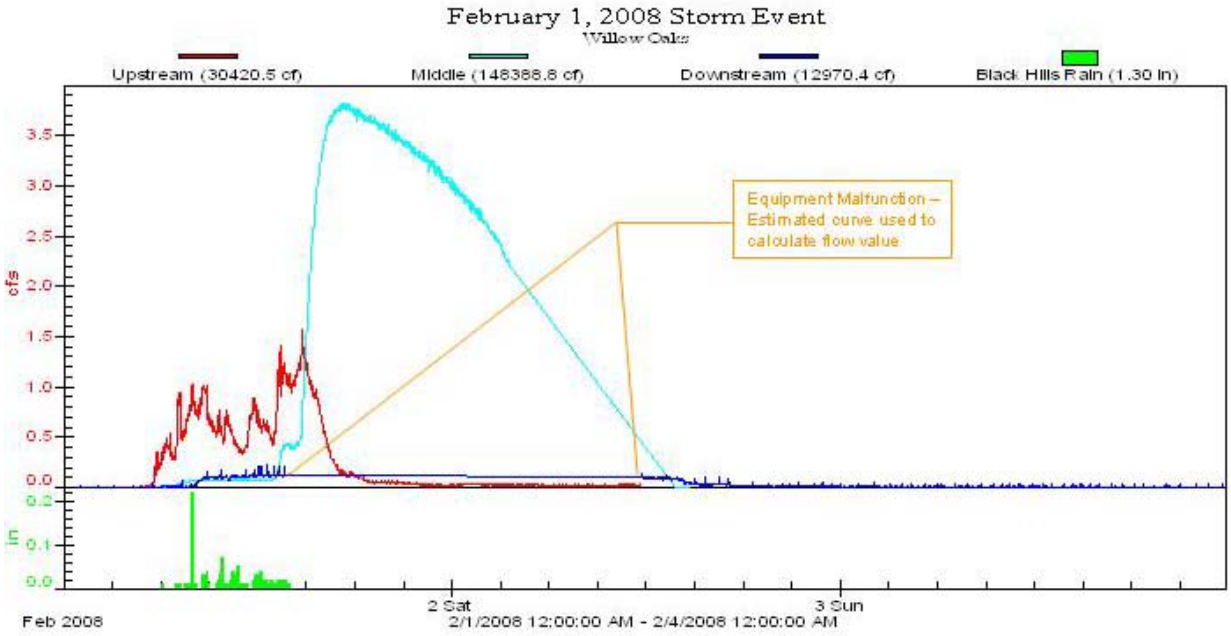

Figure TA-3.17. Hydrograph and rainfall for the Willow Oaks February 1, 2008 storm (Jones 2008b).

Table TA-3.20. Willow Oaks storm concentrations and loadings of metals. Loadings are not calculated if flow value is inaccurate and not presented if concentration was below the detection limit. A negative percent reduction indicates that more of pollutant is leaving the system than is entering.

	Cadmium				Copper				Lead				Zinc			
Storm Date	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)
Analytical Concentration (mg/L) and Pollutant Reduction (%)																
7/7/2005	B.D.L.	B.D.L.	B.D.L.	n.c.	0.005	0.006	0.008	-60.0%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.022	0.021	0.023	-4.5%
10/24/2005	B.D.L.	B.D.L.	B.D.L.	n.c.	0.009	0.01	0.006	33.3%	B.D.L.	B.D.L.	B.D.L.	n.c.	B.D.L.	0.01	0.012	n.c.
1/22/2006	B.D.L.	B.D.L.	B.D.L.	n.c.	0.011	0.008	0.011	0.0%	0.0032	B.D.L.	B.D.L.	n.c.	0.0619	0.0221	0.0277	55.3%
4/21/2006	B.D.L.	B.D.L.	B.D.L.	n.c.	0.017 (†)	0.012	0.01	41.2%	0.004	B.D.L.	B.D.L.	n.c.	0.041	0.016	0.012	70.7%
9/28/2006	B.D.L.	0.0007	B.D.L.	n.c.	0.021 (†)	0.110 (†)	0.015 (†)	28.6%	0.003	0.015	B.D.L.	n.c.	0.068	0.14 (†)	0.028	58.8%
10/17/2006	B.D.L.	B.D.L.	B.D.L.	n.c.	0.008	0.008	0.009	-12.5%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.042	0.028	0.027	35.7%
11/16/2006	B.D.L.	B.D.L.	B.D.L.	n.c.	0.007	0.009	B.D.L.	n.c.	0.003	B.D.L.	B.D.L.	n.c.	0.054	0.048	B.D.L.	n.c.
4/11/2007	B.D.L.	B.D.L.	B.D.L.	n.c.	0.0083	0.0093	0.0078	6.0%	0.0023	B.D.L.	B.D.L.	n.c.	0.062	0.0446	0.0616	0.6%
12/15/2007	B.D.L.	B.D.L.	B.D.L.	n.c.	0.0058	0.01	0.0093	-60.3%	B.D.L.	B.D.L.	B.D.L.	n.c.	B.D.L.	0.021	0.041	n.c.
2/1/2008	B.D.L.	B.D.L.	B.D.L.	n.c.	0.005	0.0074	0.0087	-74.0%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.018	0.012	0.017	5.6%
3/4/2008	B.D.L.	B.D.L.	B.D.L.	n.c.	0.0068	0.0092	0.0097	-42.6%	0.002	B.D.L.	B.D.L.	n.c.	0.027	0.013	0.014	48.1%
3/7/2008	B.D.L.	B.D.L.	0.001	n.c.	0.008	0.009	0.0086	-7.5%	0.0023	B.D.L.	B.D.L.	n.c.	0.036	0.013	0.027	25.0%
3/19/2008	B.D.L.	B.D.L.	B.D.L.	n.c.	0.0086	0.0099	0.011	-27.9%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.03	0.012	0.025	16.7%
Pollutant Loadings (g) and Pollutant Reduction (%)																
7/7/2005	n.c.	*	*	n.c.	28.6	*	*	n.c.	n.c.	*	*	n.c.	125.7	*	*	n.c.
10/24/2005	n.c.	n.c.	*	n.c.	41.9	9.8	*	n.c.	n.c.	n.c.	*	n.c.	n.c.	9.8	*	n.c.
1/22/2006	n.c.	n.c.	n.c.	n.c.	30.1	3.3	3.2	89.3%	8.8	n.c.	n.c.	n.c.	169.4	9.1	8.1	95.2%
4/21/2006	n.c.	*	n.c.	n.c.	45	*	2.7	94.0%	10.6	*	n.c.	n.c.	108.6	*	3.2	97.0%
9/28/2006	n.c.	0.02	*	n.c.	13.4	3.8	*	n.c.	1.9	0.5	*	n.c.	43.3	4.8	*	n.c.
10/17/2006	n.c.	n.c.	n.c.	n.c.	9.3	0.6	0.3	96.4%	n.c.	n.c.	n.c.	n.c.	48.8	2	1	97.9%
11/16/2006	n.c.	*	n.c.	n.c.	27.2	*	n.c.	n.c.	11.7	*	n.c.	n.c.	209.9	*	n.c.	n.c.
4/11/2007	n.c.	n.c.	n.c.	n.c.	6	0.5	0.7	89.0%	1.7	n.c.	n.c.	n.c.	44.9	2.5	5.2	88.4%
12/15/2007	n.c.	n.c.	n.c.	n.c.	11.44	1.17	3.47	69.7%	n.c.	n.c.	n.c.	n.c.	n.c.	2.5	15.3	n.c.
2/1/2008	n.c.	*	0.64	n.c.	4.31	*	5.55	-28.8%	n.c.	*	n.c.	n.c.	15.5	*	10.8	30.1%
3/4/2008	n.c.	*	n.c.	n.c.	4.19	*	2.21	47.2%	1.2	*	n.c.	n.c.	16.6	*	3.2	80.2%
3/7/2008	n.c.	n.c.	n.c.	n.c.	2.71	0.53	1.32	51.4%	0.8	n.c.	n.c.	n.c.	12.2	0.8	4.1	66.1%
3/19/2008	n.c.	n.c.	n.c.	n.c.	1.97	0.39	0.82	58.1%	n.c.	n.c.	n.c.	n.c.	6.9	0.5	1.9	72.7%

* - Loading not calculated due to inaccurate flow rate measurement

(†) At or above acute criteria value (Refer to Table TA-3.18)

B.D.L - Concentration (mg/L) below detection limit (Refer to Table TA-3.18)

n.c. - Not Calculated (if concentration was below detectable limit or flow value was inaccurate)

Table TA-3.21. Willow Oaks storm concentrations and loadings of nitrogen-based nutrients (nitrate, nitrite, total Kjeldahl nitrogen (TKN), total nitrogen). Loadings are not calculated if flow value is inaccurate and not presented if concentration was below the detection limit. A negative percent reduction indicates that more of pollutant is leaving the system than is entering

	Nitrate				Nitrite				TKN				Total Nitrogen			
Storm Date	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)
Analytical Concentration (mg/L) and Pollutant Reduction (%)																
7/7/2005	0.1	0.06	0.08	20.0%	0.02	0.02	B.D.L.	n.c.	1	1.2	B.D.L.	n.c.	1.1	1.3	0.08	92.7%
10/24/2005	0.18	0.25	0.35	-94.4%	B.D.L.	0.02	0.02	n.c.	1	0.7	0.6	40.0%	1.2	0.95	0.97	19.2%
1/22/2006	0.24	0.2	0.14	41.7%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.6	0.6	0.6	0.0%	0.84	0.8	0.74	11.9%
4/21/2006	0.46	0.47	0.63	-37.0%	B.D.L.	0.04	0.04	n.c.	1.6	1	0.7	56.3%	2.1	1.5	1.4	33.3%
9/28/2006	0.59	0.46	0.42	28.8%	0.02	0.03	0.02	0.0%	B.D.L.	B.D.L.	0.8	n.c.	0.61	0.49	0.52	14.8%
10/17/2006	0.35	0.3	0.23	34.3%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.7	B.D.L.	B.D.L.	n.c.	0.42	0.3	0.23	45.2%
11/16/2006	0.25	0.15	0.23	8.0%	0.02	B.D.L.	B.D.L.	n.c.	B.D.L.	B.D.L.	B.D.L.	n.c.	0.27	0.15	0.23	14.8%
4/11/2007	1.5	2.18	2.8	-86.7%	0.02	0.02	B.D.L.	n.c.	0.9	B.D.L.	B.D.L.	n.c.	2.4	2.2	2.8	-16.7%
12/15/2007	0.35	0.3	0.23	34.3%	B.D.L.	B.D.L.	B.D.L.	n.c.	B.D.L.	B.D.L.	B.D.L.	n.c.	0.35	0.3	0.23	34.3%
2/1/2008	0.58	0.52	0.33	43.1%	B.D.L.	B.D.L.	B.D.L.	n.c.	1	0.9	0.6	40.0%	1.6	1.4	0.93	41.9%
3/4/2008	0.43	0.52	0.35	18.6%	B.D.L.	B.D.L.	B.D.L.	n.c.	4.1	3.2	2.8	31.7%	4.5	3.7	3.2	28.9%
3/7/2008	0.34	0.79	0.6	-76.5%	B.D.L.	B.D.L.	B.D.L.	n.c.	0.6	1.1	0.8	33.3%	0.94	1.9	1.4	-48.9%
3/19/2008	0.3	0.4	0.34	-13.3%	B.D.L.	B.D.L.	B.D.L.	n.c.	1	0.6	0.7	30.0%	1.3	1	1	23.1%
Pollutant Loadings (g) and Pollutant Reduction (%)																
7/7/2005	571.2	*	*	n.c.	114.2	*	*	n.c.	5712.2	*	*	n.c.	6283.5	*	*	n.c.
10/24/2005	838.8	245.3	*	n.c.	n.c.	19.6	*	n.c.	4660.1	686.9	*	n.c.	5592.1	932.2	*	n.c.
1/22/2006	656.9	82	41	93.8%	n.c.	n.c.	n.c.	n.c.	1642.2	245.9	175.5	89.3%	2299.1	327.9	216.5	90.6%
4/21/2006	1218.6	*	169.3	86.1%	n.c.	*	10.8	n.c.	4238.5	*	188.2	95.6%	5563	*	376.3	93.2%
9/28/2006	375.3	15.8	*	n.c.	12.7	1	*	n.c.	n.c.	n.c.	*	n.c.	388	16.9	*	n.c.
10/17/2006	406.4	21.8	8.6	97.9%	n.c.	n.c.	n.c.	n.c.	812.8	n.c.	n.c.	n.c.	487.7	21.8	8.6	98.2%
11/16/2006	971.9	*	22.8	97.7%	77.7	*	n.c.	n.c.	n.c.	*	n.c.	n.c.	1049.6	*	22.8	97.8%
4/11/2007	1085.2	124.6	237.1	78.1%	14.5	1.1	n.c.	n.c.	651.1	n.c.	n.c.	n.c.	1736.2	125.8	237.1	86.3%
12/15/2007	690.2	35.2	85.8	87.6%	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	690.2	35.2	85.8	87.6%
2/1/2008	499.6	*	210.5	57.9%	n.c.	*	n.c.	n.c.	861.4	*	382.7	55.6%	1378.3	*	593.2	57.0%
3/4/2008	264.7	*	79.7	69.9%	n.c.	n.c.	n.c.	n.c.	2524.3	*	637.5	74.7%	2770.5	*	728.6	73.7%
3/7/2008	115.1	46.4	91.8	20.2%	n.c.	n.c.	n.c.	n.c.	203.1	64.6	122.4	39.7%	318.1	111.6	214.2	32.7%
3/19/2008	68.6	15.9	25.5	62.9%	n.c.	n.c.	n.c.	n.c.	228.7	23.8	52.4	77.1%	297.3	39.7	74.9	74.8%

* - Loading not calculated due to inaccurate flow rate measurement

B.D.L - Concentration (mg/L) below detection limit (Refer to Table TA-3.18)

n.c. = Not Calculated (if concentration was below detectable limit or flow value was inaccurate)

Table TA-3.22. Willow Oaks storm concentrations and loadings of phosphorus-based nutrients (total phosphorus and orthophosphate) and total suspended solids (TSS). Loadings are not calculated if flow value is inaccurate and not presented if concentration was below the detection limit. A negative percent reduction indicates that more of pollutant is leaving the system than is entering.

	Total Phosphorus				Orthophosphate				TSS			
Storm Date	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)	Station 1 (In)	Station 2 (Mid)	Station 3 (Out)	Pol. Red. (In vs. Out)
Analytical Concentration (mg/L) and Pollutant Reduction (%)												
7/7/2005	0.07	0.07	0.06	14.3%	0.04	0.04	0.03	25.0%	20	5	16	20.0%
10/24/2005	0.06	0.15	0.17	-183.3%	0.02	0.09	0.12	-500.0%	5	8	6	-20.0%
1/22/2006	0.11	0.11	0.1	9.1%	0.03	0.03	B.D.L.	n.c.	18	10	24	-33.3%
4/21/2006	0.15	0.11	0.1	33.3%	0.1	0.06	0.04	60.0%	26	8	30	-15.4%
9/28/2006	0.25	0.12	0.11	56.0%	0.13	0.05	0.02	84.6%	3	16	12	-300.0%
10/17/2006	0.24	0.11	0.04	83.3%	0.18	0.05	0.02	88.9%	13	4	5	61.5%
11/16/2006	0.22	0.13	0.18	18.2%	0.13	0.09	0.1	23.1%	18	11	20	-11.1%
4/11/2007	0.33	0.12	0.11	66.7%	0.09	0.07	0.04	55.6%	120	5	7	94.2%
12/15/2007	0.14	0.1	0.09	35.7%	0.09	0.07	0.03	66.7%	22	4	12	45.5%
2/1/2008	0.19	0.14	0.1	47.4%	0.1	0.08	0.04	60.0%	6	B.D.L.	1	83.3%
3/4/2008	0.15	0.1	0.1	33.3%	0.11	0.07	0.05	27.3%	10	6	6	40.0%
3/7/2008	0.07	0.09	0.06	14.3%	0.05	0.04	0.02	60.0%	14	4	2	85.7%
3/19/2008	0.11	0.09	0.06	45.5%	0.06	0.05	0.03	50.0%	9	4	6	33.3%
Pollutant Loadings (g) and Pollutant Reduction (%)												
7/7/2005	399.9	*	*	n.c.	228.5	*	*	n.c.	114244.7	*	*	n.c.
10/24/2005	279.6	147.2	*	n.c.	93.2	88.3	*	n.c.	23300.6	7849.9	*	n.c.
1/22/2006	301.1	45.1	29.3	90.3%	82.1	12.3	n.c.	n.c.	49265.8	4098.9	7021	85.7%
4/21/2006	397.4	*	26.9	93.2%	264.9	*	10.8	95.9%	68875.5	*	8064	88.3%
9/28/2006	159	4.1	*	n.c.	82.7	1.7	*	n.c.	1908.3	550.8	*	n.c.
10/17/2006	278.7	8	1.5	99.5%	209	3.6	0.7	99.6%	15094.1	290.1	186.3	98.8%
11/16/2006	855.2	*	17.8	97.9%	505.4	*	9.9	98.0%	69974.1	*	1980.7	97.2%
4/11/2007	238.7	6.9	9.3	96.1%	65.1	4	3.4	94.8%	86812.2	285.8	592.8	99.3%
12/15/2007	276.1	11.7	33.6	87.8%	177.5	8.2	11.2	93.7%	43384.0	469.3	4474.9	89.7%
2/1/2008	163.7	*	63.8	61.0%	86.1	*	25.5	70.4%	5168.5	*	637.8	87.7%
3/4/2008	92.4	*	22.8	75.3%	67.7	*	18.2	73.1%	6156.7	*	1366.1	77.8%
3/7/2008	23.7	5.3	9.2	61.3%	16.9	2.3	3.1	81.9%	4738.4	234.9	306.0	93.5%
3/19/2008	25.2	3.6	4.5	82.1%	13.7	2	2.2	83.6%	2058.0	159.0	449.4	78.2%

* - Loading not calculated due to inaccurate flow rate measurement

B.D.L - Concentration (mg/L) below detection limit (Refer to Table TA-3.18)

n.c. = Not Calculated (if concentration was below detectable limit or flow value was inaccurate)

According to Jones (2009b):

"A Kendall Tau b test was performed on the data to determine trend over time in outfall (Station 3) concentrations and loadings overtime. A significant trend (downward) was only found when analyzing TSS concentration over time (p = 0.0489), meaning that the [flow-weighted] concentrations of TSS at the discharge decreased over the time period of the monitoring project.

An ANOVA was performed to compare dry time to outfall concentration, rain quantity to outfall concentration, dry time to outfall loading, and rain quantity to outfall loading. A significant, positive relationship was found for dry time to concentration for total Kjeldahl nitrogen [TKN] (p = 0.0191) and total nitrogen (p = 0.0291); and rainfall to loading for orthophosphate (p = 0.0438), total Kjeldahl nitrogen (p = 0.0164), and total nitrogen (p = 0.0350)."

Kendall Tau b test

This statistical analysis measures the association and significance of correspondence between two variables.

Variables are assigned rankings:
-1 = 100% negative association / perfect inversion
0 = No association
+1 = 100 % positive association / perfect agreement

In this case, the statistical test examined performance over time as chemical concentrations vs. sampling date as well as chemical loadings vs. sampling date in a tabular format.

ANOVA – Analysis of Variance

This analysis represents a collection of statistical models and associated procedures. Generally, an ANOVA examines differences among multiple groups, testing if the means are equal.

In this case, the influence of dry time and rainfall quantity were examined against chemical concentration and loading values.

Snider's Estates (Upper Paint Branch SPA)

Total suspended solids were monitored using grab sampling at Snider's Estates during construction. TSS grab sample data is presented in Table TA-3.10. Only flow leaving Pond 1 was monitored during post-construction. Pond 1 contains a surface sand filter.

An aerial image of the Snider's Estates property is provided in Fig. TA-3.18. The plan views of the SWM treatment train and monitoring locations are provided (Figs TA-3.19 and TA-3.20).

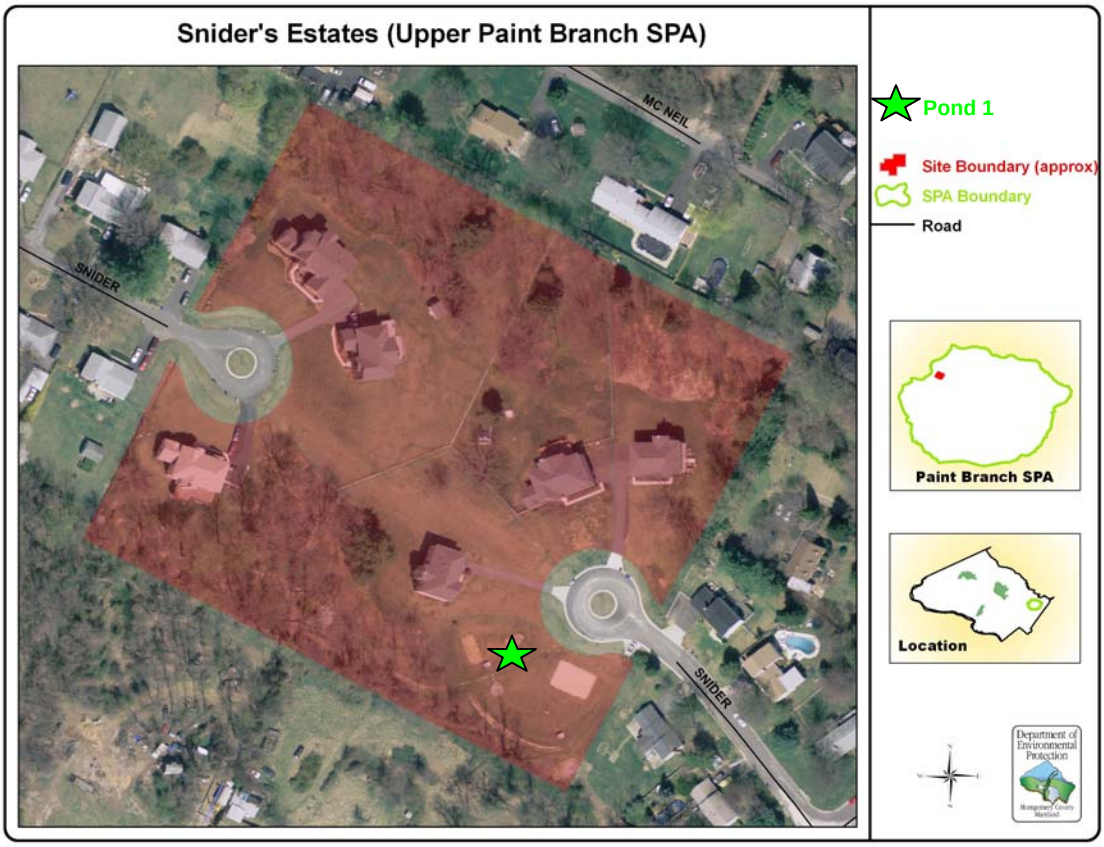

Figure TA-3.18. 2008 aerial image of Snider's Estates.

A total of fifteen storms were captured (Table TA-3.23). Only storms with a return interval >1 year were compared with the TR-20 model expected values.

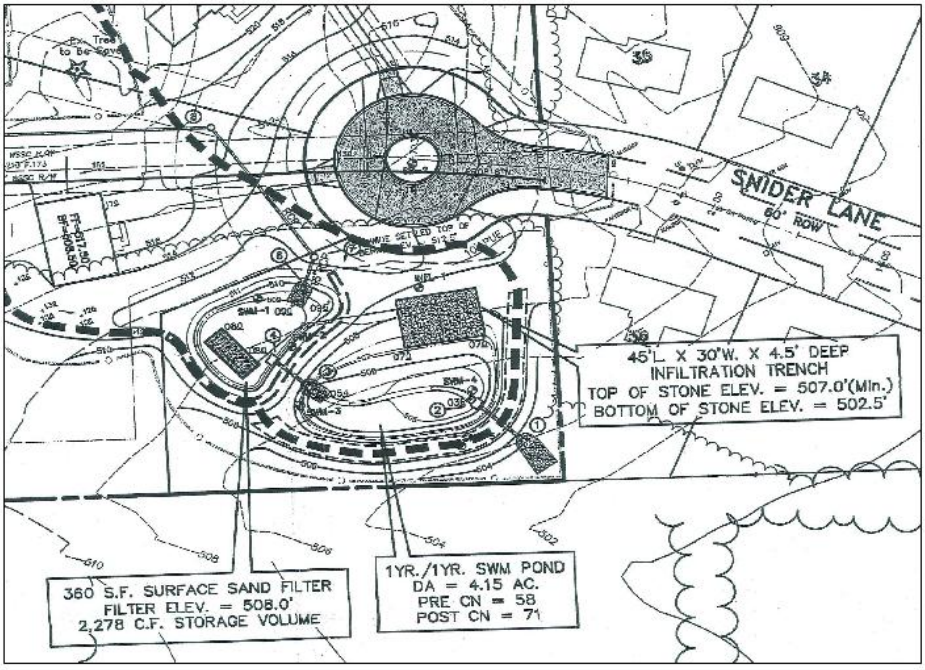

Figure TA-3.19. Snider's Estates stormwater management facility structure and drainage area detail (Jones & Schreiner 2008).

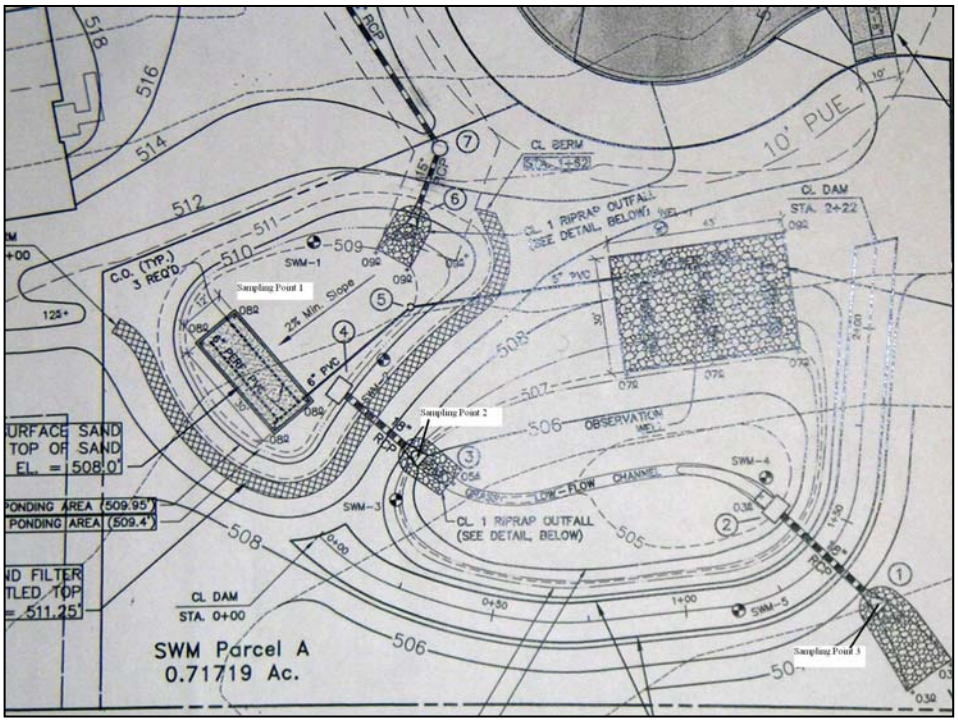

Figure TA-3.20. Plan view of Snider's Estates SWM with marked sampling locations (Jones & Schreiner 2008). The plan illustrates during construction / pre-conversion sampling points (3) and the discussed post-construction flow monitoring station (Sampling Point 2).

Table TA-3.23. Storm events measured for flow exiting Snider's Estates SWM Pond 1. Events with flow values used to compare with the simulated values are highlighted.

Date	Quantity of Rain (In.)	Dry Time (Hr.)	Rainfall Duration (Hr.)	Elevated Flow Duration (Hr.)	Average Rainfall Rate (In./Hr.)	Return Interval (Yr.)	Maximum Flow Rate (CFS)
12/23/2004	0.87	1	3.33	2.33	0.26	< 1	1.386
1/14/2005	1.99	1.83	6.83	6.67	0.29	1-2	4.554
3/23/2005	1.82	69.33	16.83	2	0.11	< 1	0.459
3/27/2005	1.00	1.17	8.5	6.83	0.12	< 1	1.678
4/1/2005	1.55	1.5	13.67	14.33	0.11	< 1	1.96
6/29/2005	1.35	10.17	3.83	1.17	0.35	< 1	0.133
7/7/2005	2.93	1	15.17	9.5	0.19	2	4.98
7/14/2005	1.49	6.5	8.83	10	0.17	< 1	2.621
7/16/2005	0.51	1.67	5.5	8.17	0.09	< 1	2.269
7/29/2005	1.17	41.67	4.17	0.67	0.28	< 1	0.271
10/7/2005	6.13	1	25.5	26.17	0.24	25	3.541
12/15/2005	1.25	122.5	10.25	3.17	0.12	< 1	0.298
6/25/2006	6.84	1.33	9.17	8.83	0.75	200	10.671
6/13/2007	1.95	3.33	2.17	0.33	0.9	5	0.042
10/24/2007	4.38	101.67	77.33	22.33	0.06	2	0.011

TA-3.4.2 Stormceptor® Results

Background

Suggested materials for information on Stormceptor® function and effectiveness:

http://www.epa.gov/region1//assistance/ceitts/stormwater/techs/stormceptor.html – Storm Water Virtual Trade Show Stormceptor® (Rinker Materials 2007)

http://www.ceere.org/ees/EES_Publications/step/Stormceptor%20fact%20sheet%20revised%20203.pdf – Stormwater Technology: Stormceptor (STEP 2003)

http://www.stormwatercenter.net/Practice/120-Stormceptor.pdf – Performance of a Proprietary Stormwater Treatment Device: The Stormceptor® (RAC 2002)

http://www.stormceptor.com/ – Stormceptor ® home page (Imbrium Systems Inc. 2007)

http://www.fhwa.dot.gov/environment/ultraurb/3fs14.htm – Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring Fact Sheet - Manufactured Systems (Shoemaker et al. 2002b)

http://www.epa.gov/OW-OWM.html/mtb/hydro.pdf - EPA Storm Water Technology Fact Sheet: Hydrodynamic Separators (US EPA 1999b).

Full citations are provided in the Literature Cited section at the end of this document.

Cloverly Safeway (Upper Paint Branch SPA)

The Stormceptor® functions as additional quality control in the stormwater treatment train utilized at the Cloverly Safeway (Fig. TA-3.21) in Paint Branch SPA. A diagram of Cloverly Safeway stormwater BMPs and sampling locations is provided (Fig. TA-3.22).

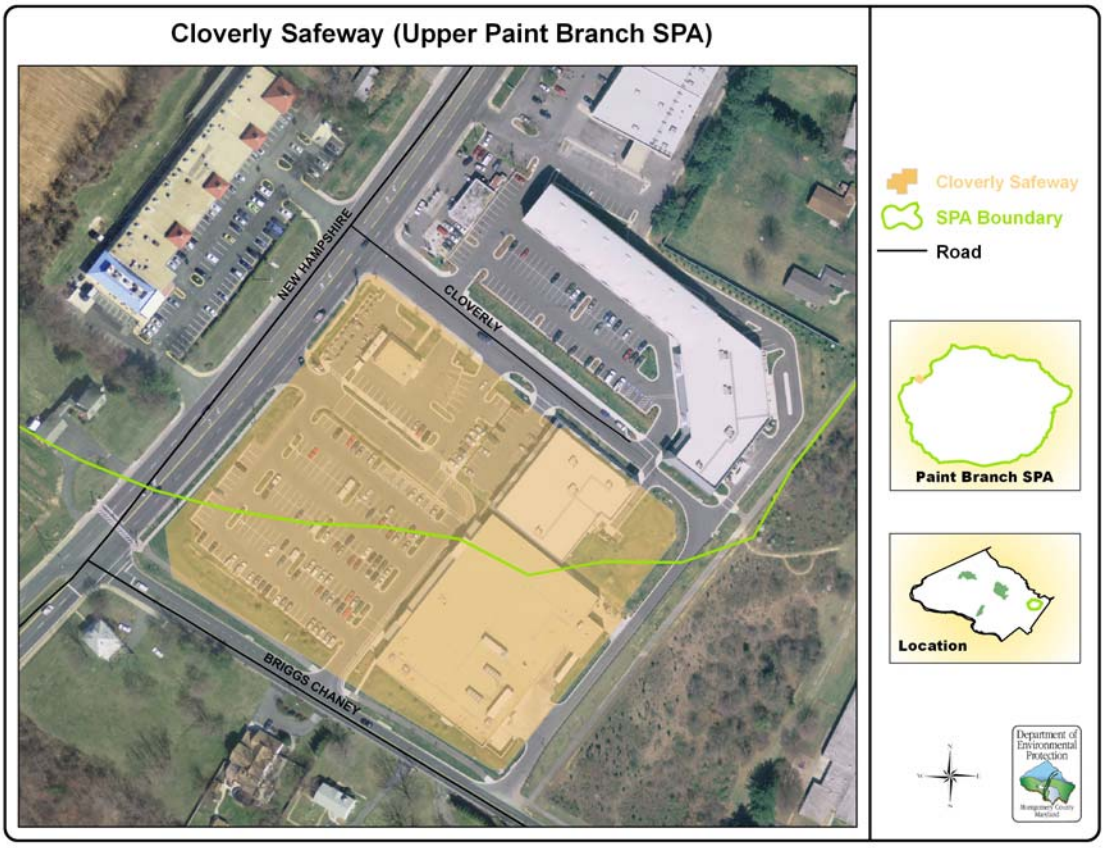

Figure TA-3.21. 2008 aerial image of Cloverly Safeway.

Post construction monitoring of stormwater chemistry as it passes through the device was conducted using automated sampling from November 2002 through June 2008. The first storm was collected in May 2003; the final in April 2008. First flush grab samples of total petroleum hydrocarbons (TPH) of influent and effluent as well as continuous monitoring of effluent temperature were also conducted.

Parameters and detection limits are provided in Table TA-3.24 (Jones 2008c). Eleven of the fifteen required storms have been captured; storm characteristics are provided in Table TA-3.25 and loading and concentration data in Table TA-3.26.

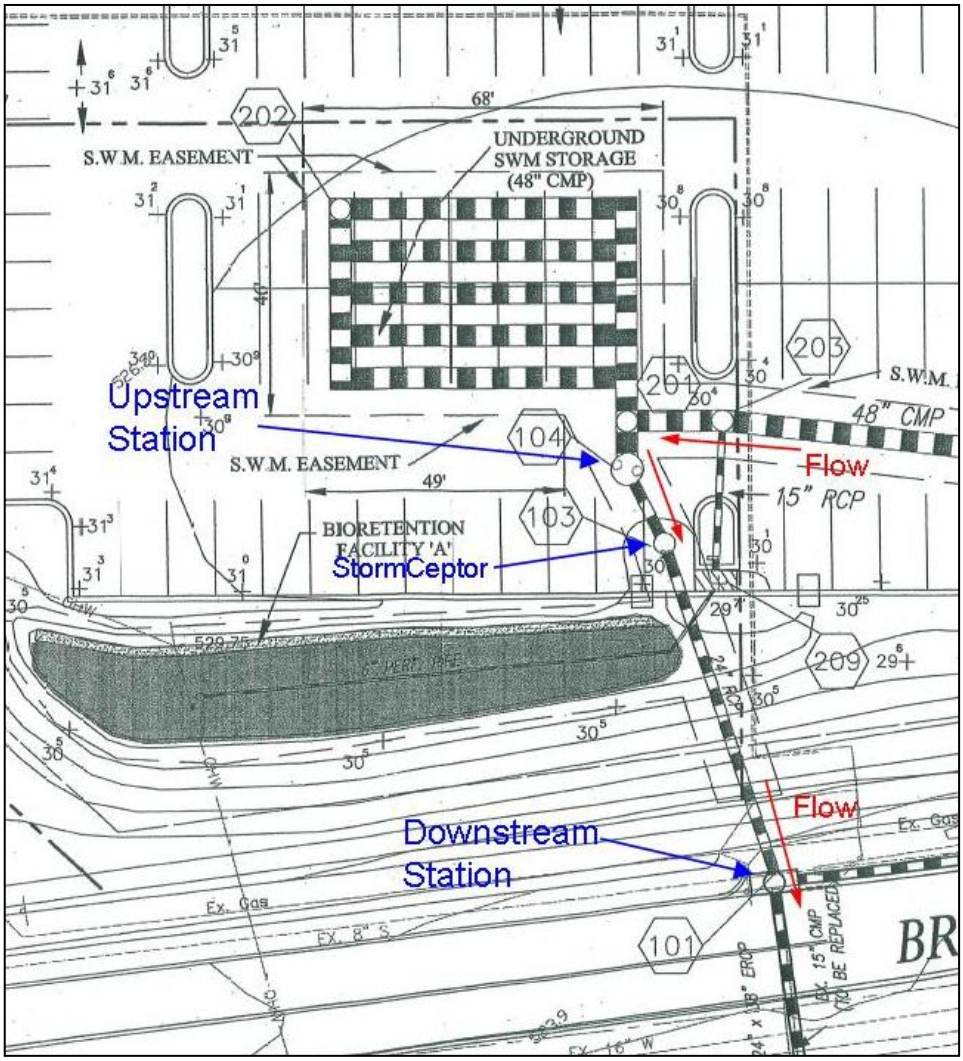

Figure TA-3.22. Diagram of Cloverly Safeway SWM BMPs with marked sampling locations (2) (Jones 2008c).

Table TA-3.24. Detection limits and Maryland water quality standards for chemicals monitored at the Cloverly Safeway Stormceptor®.

Parameter	EPA Method	Detection Limit (mg/L)	Maryland Freshwater Acute Criteria (mg/L)
Total Petroleum Hydrocarbons [a]	EPA 418.1	2	None
Cadmium	EPA 200.8	0.0005	0.002
Copper	EPA 200.8	0.002	0.013
Lead	EPA 200.8	0.002	0.065
Zinc	EPA 200.8	0.025 [b]	0.12
Total Suspended Solids [c]	EPA 160.2 & SM2540D	1	None

[a] Collected using grab sample method
[b] Zinc detection limit varies between 0.005 and 0.025 mg/L
[c] This parameter was added after the first five storms.

Table TA-3.25. Characteristics of captured storms and measured flow as part of Cloverly Safeway SPA BMP monitoring.

Storm Date	Rainfall Quantity (in.)	Rain duration (hr.)	Return interval (yr.)	Preceding drying time (h)	Effluent volume (m3) *
5/9/2003	0.31	2.0	< 1	23.5	137.2
7/28/2003	0.69	5.92	< 1	14.83	634.2
4/12/2004	1.17	12.0	< 1	107	947.7
9/28/2004	1.93	8.0	< 1	242.75	709.8
12/9/2004	0.56	7.5	< 1	38.75	550.1
5/23/2005	0.75	33.67	< 1	73	516.1
10/27/2006	1.55	31.17	< 1	159.83	1098
11/7/2006	1.66	26.5	< 1	131.33	958.3
11/15/2006	1.75	7.92	< 1	68.92	662.2
11/22/2006	1.17	27.67	< 1	140.33	701
12/22/2006	1.05	5.0	< 1	214.25	693
12/15/2007	0.99	13.5	< 1	42.5	786.8
3/4/2008	1.03	14.25	< 1	246.75	603.4
3/7/2008	0.72	28.0	< 1	54.25	357.8
4/3/2008	0.72	20.25	< 1	54.5	448.3

* - Flow was only recorded at the downstream station. The quantity of water leaving the Stormceptor© was assumed equal to the quantity entering (Jones 2009b).

Table TA-3.26. Storm concentrations and loadings of chemicals sampled at the Cloverly Safeway Stormceptor®. Loadings were not calculated for total petroleum hydrocarbons (TPH) because this parameter was collected as a "first flush" grab sample. Total suspended solids (TSS) data was not available predating 5/23/2005.

Storm	TPH		Cadmium		Copper		Lead		Zinc		TSS	
Event Date	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Analytical Concentration (mg/L)												
5/9/2003	B.D.L.	B.D.L.	B.D.L.	B.D.L.	0.012	0.012	0.003	0.003	0.13 (†)	0.12 (†)	n.a.	n.a.
7/28/2003	B.D.L.	B.D.L.	0.0061 (†)	0.005 (†)	0.011	0.013 (†)	0.01	0.161 (†)	0.072	0.079	n.a.	n.a.
4/12/2004	B.D.L.	B.D.L.	B.D.L.	B.D.L.	0.008	0.008	0.003	0.002	0.068	0.057	n.a.	n.a.
9/28/2004	B.D.L.	B.D.L.	B.D.L.	B.D.L.	0.01	0.008	0.003	0.003	0.037	0.034	n.a.	n.a.
12/9/2004	3	3	B.D.L.	B.D.L.	0.008	0.006	B.D.L.	B.D.L.	0.039	0.029	n.a.	n.a.
5/23/2005	2	7	B.D.L.	0.0023 (†)	0.008	0.004	B.D.L.	B.D.L.	0.062	0.034	17	6
10/27/2006	n.s.	n.s.	B.D.L.	B.D.L.	0.016 (†)	0.006	0.004	B.D.L.	0.2 (†)	0.05	140	5
11/7/2006	n.s.	n.s.	B.D.L.	B.D.L.	0.006	0.005	B.D.L.	B.D.L.	0.057	0.074	9	7
11/15/2006	3	5	B.D.L.	B.D.L.	0.005	0.005	B.D.L.	B.D.L.	0.062	0.056	47	20
11/22/2006	n.s.	n.s.	B.D.L.	B.D.L.	0.005	0.004	B.D.L.	B.D.L.	0.071	0.057	8	8
12/22/2006	n.s.	n.s.	B.D.L.	B.D.L.	0.006	0.007	0.004	0.005	0.081	0.072	10	10
12/15/2007	n.s.	n.s.	B.D.L.	B.D.L.	0.0079	0.0074	B.D.L.	B.D.L.	0.04	0.03	8	8
3/4/2008	n.s.	n.s.	B.D.L.	B.D.L.	0.0041	0.005	B.D.L.	B.D.L.	0.041	0.037	16	20
3/7/2008	n.s.	n.s.	B.D.L.	B.D.L.	0.0047	0.0048	B.D.L.	B.D.L.	0.036	0.03	6	11
4/3/2008	n.s.	n.s.	B.D.L.	B.D.L.	0.0058	0.0048	B.D.L.	B.D.L.	0.035	0.024	3	3
Pollutant Loadings (g)												
5/9/2003	n.c.	n.c.	n.c.	n.c.	1.6	1.6	0.4	0.4	17.8	16.5	n.a.	n.a.
7/28/2003	n.c.	n.c.	3.9	3.2	7	8.2	6.3	102	45.7	50.1	n.a.	n.a.
4/12/2004	n.c.	n.c.	n.c.	n.c.	7.6	7.6	2.8	1.9	64.4	54	n.a.	n.a.
9/28/2004	n.c.	n.c.	n.c.	n.c.	7.1	5.7	2.1	2.1	26.3	24.1	n.a.	n.a.
12/9/2004	n.c.	n.c.	n.c.	n.c.	4.2	3.3	n.c.	n.c.	20.6	16	n.a.	n.a.
5/23/2005	n.c.	n.c.	n.c.	1.2	4.1	2.1	n.c.	n.c.	32	17.5	8773.1	3096.4
10/27/2006	n.s.	n.s.	n.c.	n.c.	17.6	6.6	4.4	n.c.	219.6	54.9	153724.9	5490.2
11/7/2006	n.s.	n.s.	n.c.	n.c.	5.8	4.8	1.9	n.c.	54.6	70.9	8625.1	6708.4
11/15/2006	n.c.	n.c.	n.c.	n.c.	3.3	3.3	n.c.	n.c.	41.1	37.1	31122.1	13243.4
11/22/2006	n.s.	n.s.	n.c.	n.c.	3.5	2.8	n.c.	n.c.	49.8	40	5607.9	5607.9
12/22/2006	n.s.	n.s.	n.c.	n.c.	4.2	4.9	2.8	3.5	56.1	49.9	6929.6	6929.6
12/15/2007	n.s.	n.s.	n.c.	n.c.	6.2	5.8	n.c.	n.c.	31.5	23.6	6294.4	6294.4
3/4/2008	n.s.	n.s.	n.c.	n.c.	2.5	3	n.c.	n.c.	24.7	22.3	9653.7	12067.1
3/7/2008	n.s.	n.s.	n.c.	n.c.	1.7	1.7	n.c.	n.c.	12.9	10.7	2147.0	3936.1
4/3/2008	n.s.	n.s.	n.c.	n.c.	2.6	2.2	n.c.	n.c.	15.7	10.8	1345.0	1345.0

B.D.L. - Below Detection Limit (Refer to Table TA-3.24)

(†) At or above acute criteria value (Refer to Table TA-3.24)

n.c. - Not Calculated (Loadings not calculated if concentration was below detectable limit and since TPH was collected as a "first flush" grab)

n.s. - Not Sampled

n.a. - Not Available

TA-3.5 Discussion of SPA BMP Effectiveness

There are no technical appendix materials for this section.

Note to Reader

For more information on Section 3 or technical appendix materials, please contact DEP at AskDEP@montgomerycountymd.gov, 240-777-7700.

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